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ABSTRACT

This guide is intended to assist counselors by providing occupational information about high-technology careers and by providing background information about high technology and its potential impact on the entire occupational structure. The first chapter defines the term "high technology" and includes an overview of how technology is affecting all occupations. In the second chapter, personal accounts of technicians involved in the fields of science, engineering, and technology are provided along with a description of the levels of preparation required for four high-technology careers. The third chapter examines the kind of educational preparation that is currently recommended by many employers and educators for high-technology technicians. Included in the fourth chapter are 36 suggested career education activities with a high-tech content that are keyed to general guidance objectives, a discussion of future trends that promise to influence career guidance professionals, and an assessment of the problems and possibilities of computer-assisted guidance. The final chapter lists sources of labor market information and resources for career guidance in high technology. Appendixes to the guide include a description of a course on principles of technology, a working model for pretechnical studies, charts and illustrations, resource addresses, and sample letters for use in conducting a high-tech career information search. (MN)

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HIGH-TECHNOLOGY CAREERS

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A GUIDE FOR COUNSELORS

HIGH-TECHNOLOGY CAREERS

A GUIDE FOR COUNSELORS

Daniel M. Hull
Carolyn A. Prescott

THE CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

601 C LAKE AIR DRIVE
WACO, TEXAS 76710

AUGUST 1984

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EXECUTIVE SUMMARY

Many discussions of high technology include a lot of razzle-dazzle; on reading them, people sometimes feel themselves to be the objects of persuasion or the victims of future shock. The purpose of this guide is not to sell high tech to the counselor nor to project a science fiction future. But high technology does exist under all the present media hype, and for many, it is both compelling and futuristic. Furthermore, many of today's students are genuinely excited about it.

The nation's occupational structure has already undergone changes as a result of developing technologies. High technology is creating new jobs, changing old ones, and altering the concentration of employment in various sectors of the economy. These changes are generating discussions about corresponding educational reforms. Counselors are in an especially critical position with regard to high technology. They cannot wait until the curriculum debates die down or until the occupational structure stabilizes.

Counseling professionals must provide direction and career information to students now. Counselors need current information about the scope of high technology, skill requirements of high-tech jobs, and pertinent sources of related labor market information. This document is intended to provide such information. The guide not only addresses present workforce needs but also attempts to explain how and why technology is changing so fast and what its impact may be. The depth of treatment is intended to give counselors a background that will prove useful in the changing years ahead.

This guide is intended to aid counselors in two ways:

- To provide occupational information about high-technology careers.
- To provide background information about high technology and its potential impact on the entire occupational structure.

It is recognized that counselors serve at least two groups of students with differing needs:

- Students who have made no career decisions need general information about high technology. Females, minorities and handicapped students are often in this group of undecided students, and they need not only information but also encouragement to consider high-tech careers.
- Vocational-technical students and some preprofessional students need specific career information and experiences to further define their career goals in high technology.

The rationale of this guide is that counselors will find the following information helpful in serving these two groups of students. Chapters I and II contain resource information considered appropriate for student use. The charts and illustrations included throughout the guide are provided in

full page form in Appendix C to make transparencies for classroom use. Several sections of the first two chapters may be excerpted for class distribution.

CHAPTER I defines the term "high technology." Some key technological developments are described--computers, lasers, industrial robots, and several biotechnical innovations. The background knowledge contained in the section called "Current Developments" is important for the counselor's technological literacy and is suggested as the starting point for a high-tech unit taught to students.

Chapter I also includes an overview of how technology is affecting all occupations and a summary of the corresponding educational requirements under discussion throughout the country.

CHAPTER II describes the levels of preparation required for four high-tech careers: scientist, engineer, technician and operator. The high-tech career that many people know the least about and yet that is the most relevant to most vocational-technical students is that of the technician; therefore, the role of the technician is described in detail. Personal accounts of technicians concerning various aspects of their jobs are included and are suggested for use with students to help them gain a more vivid concept of what technicians do.

CHAPTER III describes the kind of educational preparation that is currently recommended by many employers and educators for high-tech technicians. The need for articulated programs is discussed; and some of the obstacles to program changes are outlined in the section called "The Polarization Between Vocational and Academic Approaches." Chapter III suggests that vocational-technical students may wish to strengthen their math and science backgrounds and learn computer fundamentals, and that these and other program changes are appropriate topics for debate and discussion among counselors and vocational educators.

CHAPTER IV speaks to the most immediate needs counselors have for career guidance in high technology. Many counselors will find it the most helpful chapter in a practical sense. Following a short discussion of current concepts of career guidance, thirty-six suggested career education activities with a high-tech content are keyed to general guidance objectives. Chapter IV also contains a section on future trends that promise to influence career guidance professionals. The final section of Chapter IV describes computer-assisted guidance, identifying some problems and possibilities in its use.

CHAPTER V lists sources of labor market information and resources for career guidance in high technology. A sample letter is provided for counselors who wish to solicit high-tech career information from firms in their state or local community.

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CHAPTER I. WHAT IS HIGH TECHNOLOGY?

IN THIS CHAPTER ...

- A definition of high technology.
- A description of some current developments in these high-technology areas: computers, automated manufacturing and robotics, lasers and fiber optics, and biotechnology.
- The impact of high technology on the occupational structure.
- The educational requirements in a high-tech society.

DEFINING HIGH TECHNOLOGY

In recent years, the industrial community has attached the label "high technology" to many different fields, using it to describe the most advanced systems and processes in the modern world--and with good cause. High technology refers to the most recent applications of research in the physical, biological, and information sciences, especially those applications that use artificial or machine intelligence to extend our manual and intellectual capabilities.

High-technology industries are characterized by high levels of continuing innovation and a workforce made up of 5 to 15 percent scientists and engineers. Industries are sometimes classified as "high tech" by the percentage of research personnel on their staffs or by the percentage of their budgets devoted to research and development. According to these criteria, only a few industries would qualify as high tech; they include pharmaceuticals, computers, semiconductors, communications, aircraft and instruments (medical, scientific, and controlling instruments). However, the impact of high technology is felt far beyond these six categories. High technology is having a significant influence on the service and information industries: finance, banking, communications, software development, insurance, medical services, and data processing. And as the service and information sectors become an ever-larger portion of the nation's economy, the uses of high technology multiply correspondingly. The rapid expansion of technology is precisely what we have to grasp in order to prepare students for work in a high-tech world. We need to understand how and why technology has evolved into what is today labeled as high technology. In the following discussion, we will examine the reasons technology is growing so fast, its main characteristics, and some specific recent developments.

Technology, the physical methods or processes used to satisfy our material wants and to solve our problems, is as old as the first rock tool used by our cave ancestors. Technical change has occurred throughout the ages whenever a new method of doing things has been developed or invented.[1] During the last several decades, the rate of change has greatly accelerated. Eras can no longer be identified by a static level of technological achievement such as manufacturing by assembly; even terms like "jet age" and "computer revolution" are inadequate to encompass the character of technology today. Therefore, we speak of "high technology," and the answer to the question "What is high tech?" changes as fast as technological innovation occurs. One writer explains the dynamic nature of high technology in this way:

> Scientific and technological innovation emerges from a pool of information, and the larger this pool, the greater the likelihood of its containing the specific scientific and technological data required for further advances.[2]

This expanding pool of information is affecting both the rate of technological change and the way it takes place. For example, the old image of the solitary scientist or inventor working in the basement laboratory rarely applies to modern technological innovations. Today scientists, engineers, and technicians often work in teams; research facilities are usually large and multifaceted, belonging to the larger complex of a university or industry. Furthermore, the traditional barriers between scientific disciplines have proved neither fixed nor impassable; technical concepts are freely borrowed, reapplied, and elaborated upon in a process of continual change. Specialists may be present in great numbers, but a great deal of sharing information and "crossbreeding" of specialty areas is taking place in high-technology applications. The new systems of technology--for manufacturing, energy production, information processing, etc.--usually involve a blend of several specialty areas. As we shall see, the technicians who build and maintain these systems cannot afford to be narrow specialists; they must be oriented to the system as a whole.

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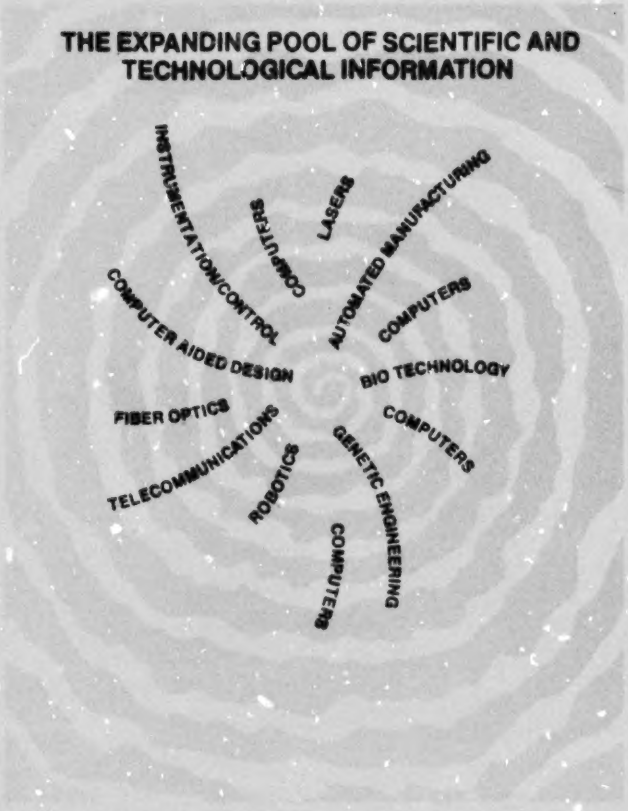
[1] Delsie Gandia. Defining High Tech (Draft). Annapolis, MD: Division of Research, Maryland Department of Economic and Community Development, May 1983.

[2] John Diebold. Man and the Computer. New York: Praeger, Inc., 1969.



As we have stated, the current rate of technological change is part of what defines high technology. In recent years, the time between a discovery and its mature implementation has decreased drastically. For example, electric motors were not put into general operation for more than fifty years after their discovery, while computers took half that long to grow from the first models into a vast industry. Integrated circuits began to be applied only three years after they were invented. If such telescoping of development time continues, we can expect changes of the same magnitude as the ones that have taken place in the last 15 years to have occurred again in the next five to seven years. Technology is already described by many as "self-generating"; that is, technology itself is pushing research into new discoveries and new dimensions.[3]

Essential to this breeding capacity of high technology is the computer, not only because computers make vast stores of information immediately accessible, but also because they are becoming capable of devising strategies with which to pursue improved solutions. Given a problem, some computers can be instructed to search the memory banks for specific information that may lead to a solution; other computers can actually "suggest" avenues of search. These heuristic, or goal-oriented, computers are part of the reason that technology is expanding so rapidly.

In the foregoing attempt to define high technology, we have emphasized two major traits: a heavy involvement with computers and a rapidly changing technical content. In addition, high technology requires a broad knowledge base and a systems-oriented emphasis on the part of technical workers. In the next section of this chapter, we will examine each of these characteristics as it relates to the education of a technical workforce.

[3] Diebold.

FOUR CHARACTERISTICS OF HIGH TECHNOLOGY

Four characteristics of high technology are significant in the education of a technical workforce: (1) broad knowledge base, (2) heavy computer use, (3) rapidly changing technologies, and (4) systems-oriented emphasis.[4]

BROAD KNOWLEDGE BASE

Today's technicians in modern industries need to know far more than that required to complete the obvious tasks and procedures associated with their jobs. Employees recognize that the complexity of today's equipment extends well beyond the simple, fail-safe devices of yesterday. Consequently, the trend in education today must be to prepare technicians who understand the entire system with which they work and the technical principles

[4]The following discussion of characteristics of high technology is taken entirely from original materials previously prepared by the Center for Occupational Research and Development, Waco, Texas.

that govern the behavior of each device. Furthermore, technicians must realize that in changing one parameter in a large system, the entire system may be altered or affected as a consequence.

At this point it is useful to distinguish between the occupations of technician and operator. The knowledge base of the technician must be much greater than that of the operator. We can illustrate this with a simplistic example. Video games are high-technology equipment; skilled engineers and technicians are required to design, develop, test, install, troubleshoot, and repair video games. Far less background is required to operate a video game; manual dexterity, good reflexes, and an abundant supply of quarters are adequate for the operator's success. On the one hand, the technician who builds and services video games must have a working knowledge of solid-state electronics, cathode-ray tube (CRT) displays, mechanical devices, switches, encoders, and combinations of computer hardware and software, while the video game operator need only learn the strategy of the machine, master a set of simple instructions, and successfully manipulate the external controls to achieve the desired result. Operator proficiency comes primarily from experience, or the number of quarters expended.

However, many of the new, so-called "operator" positions are also highly technical jobs. These include operators of electrical power plants and operators of process control equipment. Their job is not simply to follow established procedures and manipulate the plant equipment from a central control room. On the contrary, their job is to understand the chemistry, thermodynamics, and fluid flow at all points within the plant. Clearly, if the power plant operator changes one parameter--say temperature--in such a highly complex system, other critical parameters such as pressure, flow rate, water level, and water chemistry throughout the entire plant process may well be affected. It is broad understanding--in addition to operational skill--that is needed here.

HEAVY COMPUTER USE

Many modern industrial processes have become highly automated. Repetitive tasks in machining, assembly, painting and testing are accomplished by automated machines or industrial robots. These processes, machines, and robots are controlled by sophisticated computers. Other high-technology occupations require rapid access to enormous banks of information and the ability to assimilate and analyze data in "real time." Technicians working with automated equipment or data-management systems must be able to use both the software and hardware of computers and microprocessors. The development, installation, calibration, troubleshooting, and repair of most

computerized equipment require the combination of knowledge and skills found in computer programming and digital electronics.

RAPIDLY CHANGING TECHNOLOGIES

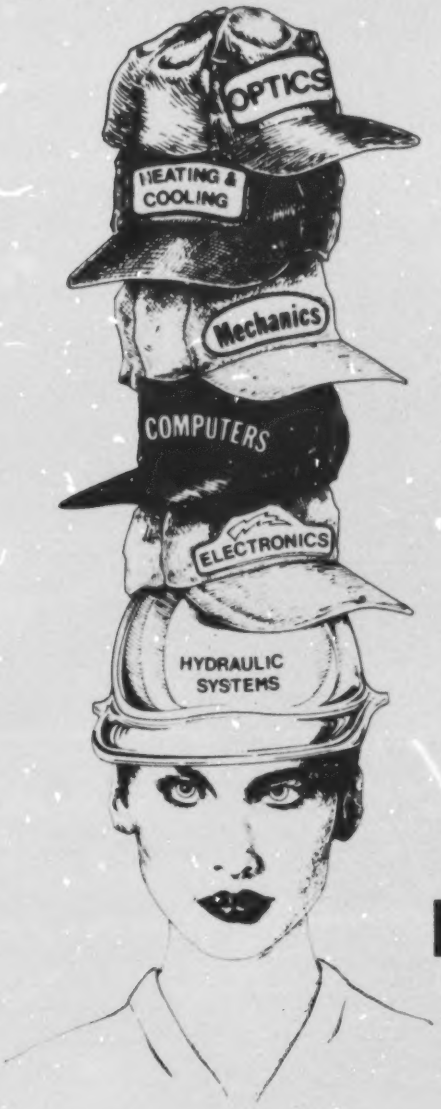
In the past thirty years, the evolution of science and technology has been characterized by rapid growth and advancement. Recent advances in telecommunications and the breakthroughs in microelectronic chips have enabled scientists, engineers, and technologists to have access to vast amounts of information and to their own powerful personal computers. This new era in data availability and computational capability guarantees that our technologies will continue to grow and change at unprecedented rates; and, indeed, the need for our country to remain competitive in the international marketplace requires that our technologies advance.

In fields such as laser/electro-optics and telecommunications, approximately fifty percent of a technical specialty changes every three or four years. Therefore, as educators, we must prepare technical workers with a broad technical and mathematical base. Only then can they continue to learn new techniques and assimilate new information after they are employed.

SYSTEMS-ORIENTED EMPHASIS

A careful examination of scientific hardware and modern industrial processes reveals complex systems that are composed of electrical, electronic, mechanical, pneumatic, hydraulic, thermal, and optical devices. The technician who works with high-technology equipment and systems must have a broad technical background to deal with such diverse systems. Specialists in electronics, mechanics, fluids or optics are still required, but the greatest need is for the "super tech" who can install, operate, maintain and repair systems that incorporate combinations of electrical motors, digital circuits, mechanisms, hydraulic actuators, lenses, light sources, and transducers. Many of these systems are controlled by microcomputers and require heating and cooling systems for proper operating temperatures.

To illustrate the need for interdisciplinary skills, let us imagine for a few moments that we are going to disassemble several pieces of typical high-technology equipment. First, let us disassemble an industrial robot. Once the cover plates are removed, we can take our wrenches, screwdrivers, and soldering irons and remove the various devices that are attached to the frame and connected to each other. Next, let us disassemble a modern, high-production photocopy machine and repeat the process. And finally, let us disassemble another modern machine such as a computer and its peripheral equipment. Now, let us examine the separate devices and parts from each



Today's technician wears a lot of HATS—

piece of high-tech equipment. We ought to see at once that the separate piles of devices for the robot, the photocopier and the computer look remarkably similar. We have piles of electrical circuits, microcomputers, switches, transformers, motors (electromechanical, pneumatic, and hydraulic), vacuum and pressure systems, heating and cooling devices, sensors and transducers, and optical imaging equipment. Indeed, these three examples of high-technology equipment have many common devices. Their uniqueness stems mostly from the way their parts are assembled to perform a particular function, rather than from a difference in the basic devices. What is probably obvious then, is that technicians working on any one of these high-tech systems could not be specialists only in electronics or mechanics, or fluids, or computers. They must have a basic understanding that spans all these fields.

The problems inherent in a singular, specialized approach to training became obvious in the laser industry in the latter part of the 1960s. The first laser operated successfully in 1960 and, in the next five to six years, engineers and scientists worked in the laboratories to create new and better laser systems and to define the underlying principles of this new technology. Lasers were ready for useful and unique applications, but laser equipment was not reliable. Laser technicians were needed. Attempts were made to cross-train electronic and mechanical technicians in such areas as lasers, optics, fluid systems and cooling systems. But because of their narrow technical base, existing specialists in electronics and mechanics were, for the most part, unsuccessful in acquiring the principles and skills

needed to function as skilled laser technicians. The broad base was not there, and cross-training was difficult, if not impossible.

CURRENT DEVELOPMENTS

High-technology careers are in the making with every new technological application. In Chapter II, we will explore more fully the qualifications needed for these careers and the type of work involved for the technician and operator. First, however, it will be useful to have an overview of current developments in several high-tech fields and of the impact of these developments on other occupations.

COMPUTERS

A good place to begin is in the area of information processing. With its huge memory and lightning-fast retrieval capacity, the computer is the ideal instrument for storing and retrieving information as well as calculating problems too complex and lengthy to be handled by conventional means.

How does a computer work? The computer is made up physically of electromechanical and electronic components arranged in metal cases and cabinets known as modules. Even small home computers have very powerful computational capability today, because they contain hundreds of thousands of digital circuits in small electronic devices called integrated circuits. Integrated circuits are tiny platforms (some no bigger than a fingernail) that carry large arrays of switches and other circuit components. A single chip of silicon might carry tens of thousands of digital circuits that have been built up on the surface of the chip photographically, one layer at a time.

Modern digital computers work by a sequence of switches that, in an "on" or "off" position, form a code. (You can conceive of this by imagining a fast Morse code; instead of short-long, this code consists of on-off.) Computers use what is called a binary code, in which switches, by being on or off, stand for one or zero. All numbers, letters, and symbols are represented by combinations of ones and zeros. For example, the binary equivalent of the integer 6 is 110. The capital letter A can be indicated as 10000001. This system would be unbelievably clumsy and complicated for human brains. But the circuitry of a computer works so fast that it is very efficient to use the binary code. In today's computers, signals travel so fast that we now measure calculation time in nanoseconds--billionths of a second. We know that a nanosecond has the same relationship to a second as a second has to thirty years.[5]

A computer system is generally made up of four modules: an input device, usually a keyboard; a central processing unit known as a CPU; a storage device, frequently a disk drive; and an output device such as a cathode-ray tube display (like a television screen). The heart of the computer is

[5]Diebold.

the CPU, which has been compared to a brain capable of certain tricks, but unable to remember what those tricks are.[6] The CPU contains the very basic capabilities built into the computer by the manufacturer. When you put a program into the computer, usually by inserting a programmed disc, it causes the computer to "remember" its basic intelligence, but it still will do nothing for you until you give it instructions by means of the keyboard. If you want to see what the computer is doing or what is has recorded, you look at the screen. Some computers are equipped with a printer that will provide a paper copy of the work.

Computer programs are written in a simplified language. Computer programmers are "translators" between people and machines because they take human language and translate it into a condensed language that is more easily transferable to the machine's binary code. To program the computer, you have to know the appropriate computer language. Fortunately, most personal computers today are programmed to receive instructions and provide feedback in familiar English, so most people who can use a keyboard can use a computer. That being the case, computers are being applied ever more frequently to a variety of problems and situations.

The computer has assumed a great percentage of routine accounting and recordkeeping functions--freeing large numbers of people from the deadening pace of rote filing and calculation, and accelerating routine transactions and interactions such as banking, payroll calculations, and stock inventory. Information stored in this manner can be retrieved in seconds and manipulated in a variety of ways. For example, with the aid of computers a company can monitor the sales of products continuously, thus determining when to increase or decrease production of items according to demand.

The speed of the computer makes it ideal for the control of some industrial plant operations in which instrumentation can provide the computer with information about given operations; in turn, the computer can transmit instructions to electromechanical parts that control the process. For example, in chemical refining plants, materials that flow through pipelines are generally affected by variables such as temperature, pressure, density, and chemical composition, to name a few. Some of these variables are subject to rapid change and some, if they change by even a small degree, must be corrected immediately. Computers can keep track of all of these variables at once. Through proper instrumentation and programming, computers can activate temperature or pressure changes, add chemicals, or make other necessary changes. This kind of computer monitoring is called process control.

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[6] "The Computer," Consumer Reports. Sept. 1983.

In medicine, computers have made a significant contribution to record-keeping and data retrieval. Physicians can now review medical case histories, lab reports, and the information given by cardiac monitoring machines--all within a half hour of a heart attack victim's admittance to the hospital. Computers are an integral part of many of the monitoring and testing devices of biotechnology.

As we have indicated, the leading edge of technology is continuously extended by computer technology. Scientists and engineers can process huge arrays of information, incorporating many more variables than would be possible otherwise, thus arriving at more truthful conclusions, more accurate descriptions of natural events (such as chemical interactions on the molecular level), and far more useful designs for machines, buildings, bridges, automobiles, and airplanes. For example, engineers can describe the characteristics of a car in mathematical terms, feed them into a computer and determine the results of various types of automobile crashes without so much as turning the key in the ignition.

The major impact of the computer on all occupations results from its use as an integral part of job equipment and processes. The clerical functions of bookkeeping, recordkeeping, filing, storing, shipping and receiving now involve the use of computers. The word processor, now used by reporters on most daily newspapers across the country, has changed the processes of composing and printing. In auto repair, the troubleshooting of electrical systems, engines, and other parts has been simplified and improved by the introduction of computerized equipment. Other job functions as varied as machining, library cataloging, cigarette manufacture, construction surveying, and retail sales involve the integration of computers in the devices and systems used to perform work.

Computer technology has also created entire industries and numerous jobs for technicians and programmers. Personnel are needed to repair and maintain computers, write programs, assemble components, design circuits, operate computers, and use word processors. Some of these are operator's jobs; some can only be handled by skilled technicians who understand computer hardware as well as the nature of software, and especially, who comprehend the relationship of the computer to other equipment.

AUTOMATED MANUFACTURING AND ROBOTICS

As indicated previously, manufacturing processes have been profoundly affected by recently developed technologies. The basis of manufacturing is the shaping and joining of materials; this can be accomplished by cutting,

grinding, molding, welding, and electrical action.[7] Prior to 1960, the machine tools that perform these tasks had changed relatively little since the 1900s. But lately, significant changes have been made. These recent changes in manufacturing techniques are based on the use of sophisticated electronic control systems comprised of transducers (sensing and measuring devices), microprocessors (programmed instructions for responding to the signals of transducers), and actuators (electromechanical devices that do the work). Transducers convert such quantities as pressure, temperature, and liquid flow into electrical signals that can be processed by the circuitry of the microprocessor. A simple example of how an automated manufacturing operation is electronically controlled is that of bottling beverages.[8] Bottles moving on a conveyor cross a sensor (in the form of a light probe) that detects the presence of the cap on the bottle. At the same time, another sensor shines on the bottle. If either sensor gives a signal indicating that the cap is absent or the bottle is empty, the capping mechanism will not be activated; instead the microprocessor then "decides" to signal another mechanism that will take the proper corrective action.

More sophisticated networks of transducers, electronic controls, and actuators are used to machine parts, paint, package, label and load for transport many of the products we use today. Machining of parts is changing drastically with a process known as CNC, or computer numerical control. Traditionally, one machine tool is capable of performing one operation such as drilling, milling or lathe operation, and the metal piece being worked is transferred by hand from one machine tool to the next. With CNC, multispindle machining centers are equipped with a set of tools that can carry out a series of operations--shaping an entire piece from raw metal to finished product--under programmed instruction and without human intervention. These machining centers improve productivity as well as the quality of materials produced. Pieces can be machined with greater accuracy, to closer tolerances, and in greater complexity than they can be made by traditional machining tools. CNC machining is especially useful in the machining of toxic or radioactive materials.

Not only is the manufacturing of parts undergoing change; the design and graphic work that precedes production is also being profoundly affected by new technology. Computer-assisted drafting and design (CAD or CADD) are making it possible to draw a design on a sensitive cathode-ray tube (CRT)

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[7] David Hamilton. Technology, Man and the Environment. London: Faber and Faber, Ltd., 1973.

[8] Ibid.

display terminal and rotate the part to be viewed from all sides without further drawing! Variables such as dimensions can be entered into the computer to alter the graphic presentation appropriately. Furthermore, with the proper programming, the computer can generate the instructions needed to construct or machine a given part on a computer-controlled manufacturing device.

Robotics is perhaps the most sophisticated arrival on the automated manufacturing scene. An industrial robot is a machine tool: a programmable manipulator that can move parts or tools through a prespecified sequence of motions. The manipulator's actions can be modified to perform a new task by changing its controls or programmed instructions without changing its hardware.[9] Existing uses of industrial robots involve repetitive preprogrammable tasks such as spot welding, spray painting, casting, loading and unloading. Robots are often used on hazardous jobs in hostile environments where human workers can function only with great difficulty. The next generation of sensor-based robots is expected to perform a broader range of tasks such as inspection, assembly, grinding and buffing, and electroplating. The work of producing acute sensing devices that will simulate human touch and human vision more accurately than in current models is still laboratory-based. However, in light of current research, R2-D2 (the rough-and-ready little robot of Star Wars) seems a little less futuristic than when it first appeared on the movie screen.

Automated manufacturing and robotics are significantly changing some occupations. Welders are becoming operators of automated welding equipment. Machinists are becoming operators of computer-numerical-control machining centers. Drafters are foregoing the old tools of the trade and becoming computer-assisted drafting technicians. Some of the many technical occupations that are likely to flourish in the fields of automated manufacturing and robotics include the following: Computer-Assisted Design Technician, Computer-Assisted Graphics Technician, Computer-Assisted Manufacturing Specialist, Computer-Integrated Manufacturing Programmer, and Industrial Robot Production Technician.

LASERS AND FIBER OPTICS

Lasers produce a very intense light, containing a great deal of power concentrated within a very narrow beam that can be controlled to accomplish various tasks. Three properties of laser light contribute to its usefulness. First of all, the laser is unlike ordinary light sources, because it

[9]Robotics Report, Carnegie-Mellon.

can be concentrated into a narrow beam having a single direction. Second, the laser consists of a very narrow range of wavelengths of light making it almost specularly pure. Laser light, therefore, consists of a "single" color of light. We say that it is monochromatic. Third, laser light forms an orderly pattern as it travels through space. Laser light is to ordinary light as a company of trained, marching soldiers is to a sprawling crowd. The laser light's quality of staying "in step" or "in phase" is referred to as coherence. The intensity of laser light results partly from its coherence.

How is laser light produced? Without providing a detailed explanation, we can say that laser light is generated when a source of energy such as an electric current is arranged to interact with a medium (which may be a gas, a liquid or a solid) so that the medium produces light. The light is reflected by means of mirrors in such a way that a beam develops that has directionality, coherence, and monochromaticity. In somewhat loftier and more precise terms, the acronym LASER describes these actions as Light Amplification through Stimulated Emission of Radiation.

Lasers, of which there are many types with variable power outputs, have proved useful in cutting, welding, measuring (especially at great distances), tracking, and marking or scribing. Lasers are used to perform delicate eye surgery, weld together automobile parts, cut multiple layers of cloth by designated patterns for garments, and measure precisely the rendezvous distance in space shuttle docking maneuvers in outer space. The development of the laser has spawned careers in operation, maintenance, design, and construction. Laser technicians are employed in areas as diverse as medicine, construction, manufacturing, defense, and research and development.

The development of fiber-optics communications technology is one of the most important of the laser's applications to date. In ordinary telephones, sound is converted into electrical impulses that are transmitted along copper wires over long distances. The possibility of using light to transmit sound occurred to Alexander Graham Bell more than a century ago, but it was not until sufficiently intense light sources, i.e., lasers, were invented that this became a practical option. Since even laser light is reduced in intensity by atmospheric conditions such as fog, dust, snow, and rain, some way had to be found to protect the purity and strength of the laser light so that it could travel for long distances. The solution to this problem has been to use optical fibers--tiny threads of the purest glass or plastic, smaller in diameter than a human hair--to transmit laser light. The laser light travels down the glass fibers, capable of carrying thousands of

telephone conversations simultaneously. Glass would seem to be a highly improbable means of transmission; we associate glass with breakage. In fact, the strength of glass is comparable to that of steel, but if its surface is flawed, however slightly, it will break easily. The glass fibers used to transmit laser light are coated immediately after manufacture to protect against surface damage and to contain the transmitted laser light more efficiently.

The advantages of fiber-optics communications are enormous. The cost of optical fibers is much less than that of copper wire, and the optical fibers are capable of carrying much more information than copper wires of the same diameter. Fiber-optic communications is best suited for long communication links with many phone circuits.

While research continues in the fiber-optics field in efforts to extend the distance of transmission, to increase the carrying capacity of fibers, and to improve the clarity of transmission, the need for technicians in this new field is growing. Technicians are involved in the process of fiber fabrication, installation of cables, maintenance, and repair.

BIOTECHNOLOGY AND GENETIC ENGINEERING

For many years, while the computer industry was making headlines in the wake of electronic breakthroughs, basic biological research was proceeding with less fanfare and in relative isolation from the marketplace. During the past decade, however, there has been a revolution in applied biology that may result in substantial improvements in human health care, agricultural production, chemical processing, and environmental cleanup techniques. Some of the applications of recent biological discoveries are already evident on the economic scene as hundreds of entrepreneurs have developed companies around new techniques for producing antibodies, growth hormones, membranes and biosensors. Many of these new applications of fundamental biological research go under the name of <u>biotechnology</u>; other often-heard, more specific terms include <u>genetic engineering</u>, <u>microbiological engineering</u>, and the medical applications often called <u>biomedical engineering</u>.

Much of biotechnology is based upon the relatively recent understanding by scientists of genetic programming, of the basic chemical compounds that make genetic programming and all other life processes possible, and of the basic unit in which these chemical reactions take place in living things--that is, the cell. Genetic programming refers to the fact that every organism carries within its cells the "instructions" that direct its development. To conceive of this, imagine every organism as having both a tape that tells it how to grow and what to be like and the machinery with which

to make itself grow and develop.[10] The "tape" is actually made up of genes that are composed of nucleic acids, and the genes interact with the "machinery," that is really proteins and chemicals that produce proteins. The amazing fact is that the "machinery" (proteins and chemicals that produce proteins) is the same inside of every organism. The reason that there is such a wide variety of living things lies with the different "tapes" (genes) that direct the growth process. Soon after scientists began to understand these very basic units of life--the protein chains (called DNA) that are compared here to machinery and the nucleic acids known as genes that tell the proteins when and how to synthesize--they began to understand how to isolate and manipulate them.

Gene splicing involves implanting genetic materials inside doctored bacteria that then produce the desired product according to genetic instructions. Gene splicing is still in a very early stage of development, but already it has enabled scientists to produce organic materials such as human insulin, vaccines, and human growth hormones. One of the most widely publicized developments resulting from gene splicing has been the capability of producing large amounts of interferon, a substance that helps the body's natural defenses attack tumors and viruses. Interferon occurs naturally in human blood, but extracting it is costly, and for a time that prevented extensive clinical trials with interferon in the treatment of cancer patients.[11] Using gene-splicing techniques, scientists have been able to produce large amounts of interferon.

The potential applications of gene splicing are far-reaching. Scientists may eventually learn to replace defective genes with healthy ones to eliminate human hereditary diseases. Many blood diseases may become curable if researchers can develop a way to extract bone marrow (in which the red blood cells are formed) and to insert the correct blood-forming genes into the marrow cells. The marrow cells would then be reimplanted to produce healthy blood cells.[12] Plant breeders may develop new species of plants to provide hardier and disease-resistant food supplies.

Genetic engineering has such vast potential that most people are rightly concerned about it. A few years ago, the media featured many stories about cloning and about the possibilities that scientists might someday manipulate genes to create a super race or a subhuman species. Although the

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[10] This analogy is given by S.E. Luria in his published lectures, 36 Lectures in Biology. Cambridge, MA: MIT Press, 1975.

[11] Eliot Marshall, "Gambling on Interferon," SCIENCE, Vol. 216, Jun. 4, 1982.

[12] Nicholas Wade, "The Question of Genetic Tinkering," Technology Illustrated, Nov. 1983.

capability to carry out such manipulations may be far in the future, scientists and nonscientists alike have already begun developing guidelines for genetic research that will protect against the misuse of such capabilities as may develop.

Other recent developments in biotechnology include the development of biosensors, tiny high-speed electronic devices that can monitor and respond to a wide range of biological reactions. Biosensors have been termed the offspring of the marriage of biology and electronics.[13] Many biosensors are made of biological material such as membranes that contain a biologically selective substance--an enzyme (proteins that cause chemical reactions to happen more readily), a cell, or an antibody--that will react to a given substance in the body. When the biological material undergoes a chemical reaction, energy is released that is transmitted by tiny connecting wires to a detector that records and displays the extent of the reaction. This kind of device allows for instantaneous measurement of certain organic materials in the body: glucose level, cholesterol, or drug abuse. In the future, biosensors may be connected to transducers that will react to the body's reaction in a helpful way: speed or slow the rate of reaction or dispense a needed drug (such as insulin in response to an elevated level of glucose). There are several kinds of biosensors intended for detecting bodily reactions. Some are optical; they measure minute light changes that result from chemical reactions; in others, the electronic components are activated by temperature changes. Biosensor research is still in the very early stages, but it may eventually mean the development of an artificial pancreas for diabetics and the automatic correction of other kinds of chemical imbalances within the human body. Biosensors may also be used to detect toxic materials and to diagnose diseases.

Biosensors are based on advances in electronic technology and on improved understanding of membranes. Membranes are porous, synthetic films with extremely fine passages that selectively pass or block molecular-sized particles. Membrane technology has developed dramatically in the last decade, and there are numerous applications based on these biotechnical advances. New membranes have been developed that are both highly permeable (allowing materials such as water to pass through them) and highly selective (preventing selected materials from passing through them).[14] The membrane technology known as reverse osmosis (RO) has led to a new type of water treatment plant. RO plants are capable of turning brackish water and seawater into pure water for steam boilers, crop irrigation and drinking.

[13]H. Garrett DeYoung, "Biosensors," High Technology, Nov. 1983.
[14]Carl Rain, "Supersieves Hit the Market," High Technology, Nov. 1983.

Other kinds of membrane technology are used in products and processes as diverse as gas separation, cold pills, breathable rainwear, metals separation and food processing.

The biotechnical developments of gene splicing, improved membrane technology and biosensors are not isolated phenomena, and they are not the sum of current activity in applied biology. Exciting prospects for the biotechnology industry have come about partly because of the simultaneous availability of these recently discovered processes. For example, materials developed through gene splicing are being used in membrane technology; advances in membrane technology are being applied to biosensors, and so forth. Biotechnology is at a point where rapid expansion is almost sure to occur. Technicians, engineers, and scientists will be a part of this growth. There are not even job titles yet for some of the jobs that are likely to be created in this exciting new field, but it seems certain that technicians with a knowledge of both physical and biological principles will be in demand.

The advancing technologies described here are by no means a complete catalog of current technological change. We have not even touched upon improved satellite communications, innovations in food processing and preservation, and nondestructive testing; these and other areas of innovation are reasonably expected to change the occupational outlook for generations of Americans to come. This brief examination of high-tech innovations is intended to provide a brief orientation for the guidance counselor who is motivated to understand high technology and its impact on society and students.

THE IMPACT OF TECHNOLOGY ON THE OCCUPATIONAL STRUCTURE

The impact of technology on society includes and goes beyond the need for a technical workforce. The entire occupational structure of our nation is changing: the manual and manufacturing occupations of the past are giving way to service, technical, and professional occupations. With this shift we have entered an "information age." John Naisbett, social forecaster and author of Megatrends, estimates that 60% of all Americans presently work in what may be called "information jobs" as programmers, systems analysts, brokers, teachers, clerks, lawyers, accountants, technicians, librarians, and secretaries, to name a few. Many others work in service occupations. Citing an MIT study, Naisbett points out that fewer than 12% of the new jobs created in the 1970s were in the goods-producing sector and that all manufacturing operations combined account for only 13% of today's total workforce.

Many reasons are given for this dramatic shift in occupations. The new tools of information management--the computer, improved communications media, video technology--are coupled with an increase in information to be managed. What seems to be happening, as observed by P.F. Drucker and others who have written about the knowledge economy, is that more knowledge creates a need for more knowledge workers. This seems to be true even though knowledge work often involves high technology and is not considered labor-intensive in the traditional sense. Further, technology and the information it generates do not preclude the need for skill; they seem instead to require of practitioners different kinds of skills and more of them. For example, in studying the effects of the acquisition of word

processing units on a clerical staff, nine additional attributes such as problem-solving and working as a team were identified as being needed.[15]

The need for increased skills in high-technology jobs has been strongly emphasized by industry spokespersons. A survey of 691 high-technology firms across the country identified factors that influenced the regional location of high-tech companies. The attribute ranked first on the list was the availability of skilled labor; number four on the list of twelve was the presence of academic institutions.[16] Research and development parks around the country have been built with easy access to universities that provide a supply of talented labor. But high-technology firms look not only to universities to provide scientists and engineers, but also to the entire educational structure of a given region to provide support personnel.

As the information economy evolves, it could change the entire organization of work and human interaction. One writer suggests two related effects on the entire workforce.[17] The first is the decentralization of the work site. Because information can now be transmitted electronically, it arrives intact, almost immediately, from distant locations. Teleconferencing has already reduced the need for "in person" communications. In the future we may see more people in rural areas, using computers to work out of their homes in conveniently located "satellite" offices. The second effect of decentralization is the potential expansion of the workforce as previously excluded persons gain a computer link to the economy. People whose current primary responsibility is parenting, as well as disabled people and senior citizens, may expand the size of the workforce.

Another important trend affecting the future employment scene is the addition of women and minorities to the workforce. It is estimated that two of every three new workers between now and 1995 will be females and/or minorities. Efforts to eliminate discrimination and stereotyping against women and minorities should help to equalize the distribution of those groups into positions of higher pay and greater prestige. For example, currently women are only 10% of all students preparing for technical occupations, but as more young women become informed about the benefits and challenges of high-tech careers, that percentage can be expected to grow.

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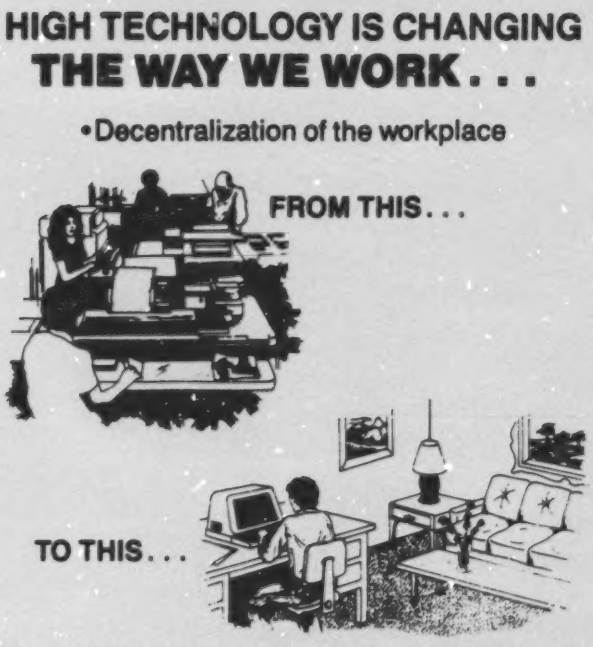
[15] C. Hayes, quoted by Mary Cianni-Surridge. "Technology and Work: Future Issues for Career Guidance," The Personnel and Guidance Journal. Mar. 1983.

[16] Report of the Governor's Ad Hoc Committee on High Technology. Maryland: Oct. 1982.

[17] Cianni-Surridge.



For many people, the most disturbing aspect of the new information economy is increasing automation. Computer technology is creating new jobs and upgrading the skills required for others, but it is also causing some jobs to disappear. With increased competition from Japan, Western Europe, and other countries, U.S. firms have turned to automation as a means of increasing productivity and of reducing labor costs. Forecasts vary widely concerning the reduction of employment from automation; estimates have ranged wildly from 5% to 75% of machine operation jobs over the next two decades.[18]

However, displacement of workers is not a distant problem; it is a contemporary one. During the decade of the 70s, hundreds of automobile workers lost their jobs as a result of a recessive economy, increased automation, and foreign competition. Some of those who were laid off have been called back in recent months, and some have been retrained within the industry. But a portion of the unemployed auto workers are still unemployed and no longer expect to be called back. Another example of worker displacement by automation has occurred among typesetters who worked on the now antiquated linotype machines. Newspapers around the country reduced the employment of typesetters during the 70s with the increased automation of printing processes. A study of 44 displaced typesetters revealed that one year after their layoff, three-fourths of the typesetters had found work outside of their field; the average salary of those employed was $11,000 per year, or less than half of that previously earned.[19] Similar

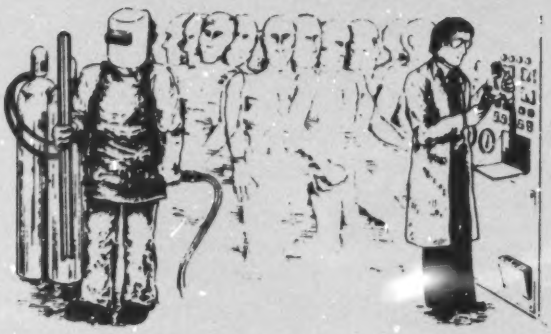
[18]Blake Conrish. "The Smart Machines of Tomorrow," The Futurist. Vol. XV, No. 4, Aug. 1981.

[19]Gilchrist and Shenkin. "Disappearing Jobs," The Futurist. Feb. 1981.

HIGH TECHNOLOGY SOMETIMES LEADS TO

WORKER DISPLACEMENT

- Some people **LOSE JOBS**
- Some people **RETRAIN** within the company or in a related field.
- Some people **CHANGE CAREERS** entirely.



wage cuts have been reported for laid-off steel and iron workers in Michigan--even after retraining.[20] As has been observed in many similar studies, the cost of displacement for the typesetters was not only economic; both workers and families experienced stress, depression, and frustration as a result of the layoffs.

Fortunately, this grim picture is offset by several factors. Displaced workers are receiving help in many forms and, in many cases, they are displaced under conditions that mitigate the economic impact of job loss. First, many employees are provided substantial severance pay when their resignation is involuntary. Some older workers are finding early retirement plans offered by their companies attractive financially and personally. Most notably, many large firms are committed to retaining experienced workers, even if it means retraining. Several high-technology firms in the Austin, Texas, area have joined to subsidize (with equipment and space) a high-technology training center. Interested workers are tested and counseled at the local community college career center, and they make informed choices about retraining in conjunction with a company personnel manager. One of these firms works individually with each employee to plan a long-term career path within the company.

From these and similar stories, we can conclude that although worker displacement by automation is a continuing problem, it is not without solutions. And although some continue to debate the wisdom or appropriateness of automation, its success in increasing production and cutting labor costs is its fastest selling point. It now seems inevitable that periods of unemployment will confront many in their adult life,[21] not only through

[20] Levin and Rumberger. "The Low Skill Future of High-Tech," Technology Review. Aug./Sept. 1981.

[21] Herr and Watts quoted by Cianni-Surridge.

displacement by automation but also through personal choice. Mid-life career changes have become more common in recent years and promise to be an even more regular occurrence in the future. The better prepared we are for such changes--whether they result from personal choice, technological change, or both--the less likely we are to experience them as "displacements."

The concept of lifelong learning will also become more important in an era of constant change. In terms of occupations, most people will have to be learners as well as practitioners in their jobs, and they may have to retrain to make job changes.

The immediate problem of worker displacement may not be as grave as the long-term reduction in middle-income jobs. Some writers have postulated our evolution into a two-class society: a professional/technical elite and unskilled (and perhaps unemployable) workers.[22] With traditional factory jobs clearly on the wane, many have looked to high-technology jobs as the "cure" for an ailing economy, and especially for the unemployment problem.[23] In support of this kind of thinking, the Department of Labor projects a faster rate of growth for high-tech jobs than for other occupations in the 1980s. For example, total employment is expected to increase by 22 percent, while employment in data processing, machine maintenance, and computer programming is expected to grow between 70 and 148 percent. The percentage growth for technicians is expected to increase more than 100% from 1981 through 1995 for most categories of paraprofessional technicians, as shown in Table 1.[24]

Because these are percentage increases, they can be misleading. The number of new high-technology jobs will still be far outweighed by the total number of new jobs in the 1980s. Five low-skilled jobs--janitors, nurses' aides, sales clerks, cashiers, and waiters and waitresses--are expected to lead all occupations in the total number of new jobs in the 80s. However, even if high-technology jobs account for only 8% of the total job growth between 1980 and 1990, more than one and a half million jobs will have been created.[25]

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[22] Cianni-Surridge.

[23] Levin and Karnberger.

[24] Supply and Demand for Scientists and Engineers. Washington, DC: Scientific Manpower Commission, 1982.

[25] Bob Kattner. "The Declining Middle," Atlantic Monthly. Jul. 1983.

TABLE 1. PROJECTED EMPLOYMENT GROWTH, 1981-1995

Paraprofessional Technician Categories	Percent Increase
Applications/Programmers	149
Engineering Aides	106
Master/Super Technicians	103
Electronic Technicians	103
Junior Technicians/Testers	139
Field Service Technicians	118
Microelectronics Technicians	144
Laser Technicians	228
Assemblers/Operators	109
Drafters	131
Design Drafters	121
Machinists	65
Other Technical Paraprofessionals	56
Total of All Paraprofessional Technicians	102

SUMMARY

In conclusion, forecasting economic and employment trends has proved difficult even for the experts. However, when we examine the figures closely, we can see significant directions and needs:

- The new economy is an information and service economy. More than 60% of all Americans presently work in information jobs.
- Traditional, semiskilled factory jobs are on the wane. Fewer and fewer young people now enrolled in school will be able to obtain such jobs.
- There will be high growth in low-skilled jobs that require little training and offer low pay.
- Two of every three new workers in the paid labor force between now and 1995 will be female and/or minority.
- High-technology industries require a trained technical workforce.
- Many economic and social factors--high technology among them--have made mid-career changes more commonplace.

EDUCATION IN A HIGH-TECH SOCIETY

Given the technological advances and the occupational shifts described in this chapter, what kind of education and skills training are needed for all of tomorrow's workforce? Is the computer going to change the skills we use to evaluate information? Do all of us need a strong science background? Do children still need drills in the basics--or can they learn instead to rely on computers? What is the place of Shakespeare's work in the curriculum of a technological society? The answers to these and other questions about the education of 21st-century Americans are to some extent subjective; they reflect current values and perspectives. If one surveys the answers given by educators, computer experts, industry leaders, and government panels, however, there is a surprising degree of consensus. All of these groups are recommending a broad basic education, and most of them are defining that as including reading, writing, mathematics, social studies, science, and computer literacy.

Within the parameters of these subject headings, the emphasis varies somewhat among different interest groups. The National Science Board Commission on Precollege Education in Mathematics, Science, and Technology defines the basics as follows:[26]

> We must return to basics, but the basics of the 21st century are not only reading, writing, and arithmetic. They include communication and higher problem-solving skills, and scientific and technological literacy--the thinking tools that allow us to understand the technological world around us.

Many high-technology companies seem to agree with that definition. For example, in a 1983 study of high-tech firms in Kansas, 60% listed basic academic courses as the first requirement for success in their businesses, although it is worth noting that under the heading of basic skills, they listed math first, followed by computer literacy.[27] Similar surveys in Los Angeles and Great Britain confirm industry preference for employees with "a sound education and a good attitude."[28]

If math and science seem to be on the lips of every educator or politician who makes a public statement, it is probably not so much because children are seen as needing more math and science than English and social

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[26] The National Science Board Commission on Precollege Education in Mathematics, Science, and Technology. Educating Americans for the 21st Century. Sept. 1983.

[27] Kansas State Department of Education. High-Technology Industry Survey. Topeka, Kansas. Jan. 1983.

[28] Levin and Rumberger.

studies as that their math and science education has been woefully inadequate for many years. Reports from all over the nation indicate that many school children are not prepared adequately in science and math. Unfortunately, reports also indicate that many students frequently lack the fundamental skills to communicate effectively in the English language. The inadequacy in science and math can be attributed in part to serious shortages of qualified math and science teachers at the elementary and secondary level. Children are frequently turned off to science and math in the early grades; student achievement in mathematics and science, as documented by national achievement tests, has declined in the past decade.

The National Science Board Commission has recommended steps to increase the number of qualified science and math teachers on every level and to increase the time-on-task in school for both subjects. In urging such measures, concerned citizens have cited the following reasons for increasing the effectiveness of math education:

- Mathematics is a way of thinking that opens doors to new knowledge in every field (art, music, social sciences).
- Mathematics is essential for the learning of science and the understanding of technology.
- The study of mathematics enhances problem-solving and logical thinking in all areas.

The study of science is seen as producing the following outcomes for students:

- Ability to formulate questions about nature and seek answers from observation and interpretation of natural phenomena.
- Development of students' capacities for problem-solving and critical thinking.
- Acquisition of scientific and technical knowledge needed to fulfill civic responsibilities in an increasingly technological world.

Besides these intrinsic rewards of science and mathematics instruction for all students, quality instruction throughout the early years provides the foundation necessary for students who wish to pursue science professionally.

Computer literacy is being recommended by many educators and industry representatives. The reasons for including computer literacy in the basic curriculum are commonly identified as follows:

- Computers are used in many jobs, so students need to become familiar with them and to understand what they can (and cannot) do.
- Even simple computer programming encourages students to think algorithmically and to develop problem-solving skills.
- Computers provide a unique educational opportunity because they permit a high degree of interaction with the learner and are

capable of simulating a learning environment. Much information can be learned through games, access to data bases, simulations, and self-testing.

Cautionary warnings have been given regarding computers in education, however. Even the most enthusiastic computer advocates agree that computers can be misused--when employed overtime as instructors or babysitters, when used with poorly developed software, and when supplied without proper orientation for the teacher.

In the high-tech world, some things will probably not change. We will continue to require an education that helps us to understand one another, to shape our values, and to realize our capacity for human feeling. The humanities must remain a vital part of every school child's curriculum. Verbal skills will continue to be a crucial part of basic education. In the information age, we need more than ever to be able to communicate effectively. In addition, the continual changes wrought by a technological society located on a shrinking planet make a strong general knowledge of social studies essential. Social studies includes our history as a species and as a nation as well as a study of different political, economic, and cultural tenets. Especially in a democratic society such as ours, these subjects are a valid and necessary part of everyone's basic education.

The components of a basic education, as they are described here and in many similar reports across the nation, are not necessarily a radical departure from the curriculum taught in many schools today. What is new is the sense of urgency with which this message about the "basics" is being voiced. Concerned citizens, parents, educators, and industry leaders are calling for a new standard of excellence for all students. They believe that American children must be provided with the appropriate intellectual tools needed for the 21st century.

EDUCATIONAL REQUIREMENTS IN A HIGH-TECH SOCIETY

BASICS

MORE MATH
MORE SCIENCE
COMPUTER FUNDAMENTALS
READING/WRITING
SOCIAL STUDIES

SKILLS

COMMUNICATION
ANALYTICAL PROBLEM-SOLVING

QUALITY

HIGHER STANDARDS OF EXCELLENCE FOR ALL STUDENTS

CHAPTER II. WHAT IS A HIGH-TECH CAREER?

IN THIS CHAPTER ...

- A description of four broad job classifications in most high-technology industries: scientists, engineers, technologists and technicians, operators and assemblers.
- Information about the role of the technician, including specific tasks and special abilities and skills required.
- Personal accounts of five technicians on the job.
- The levels or grades of technicians' jobs.

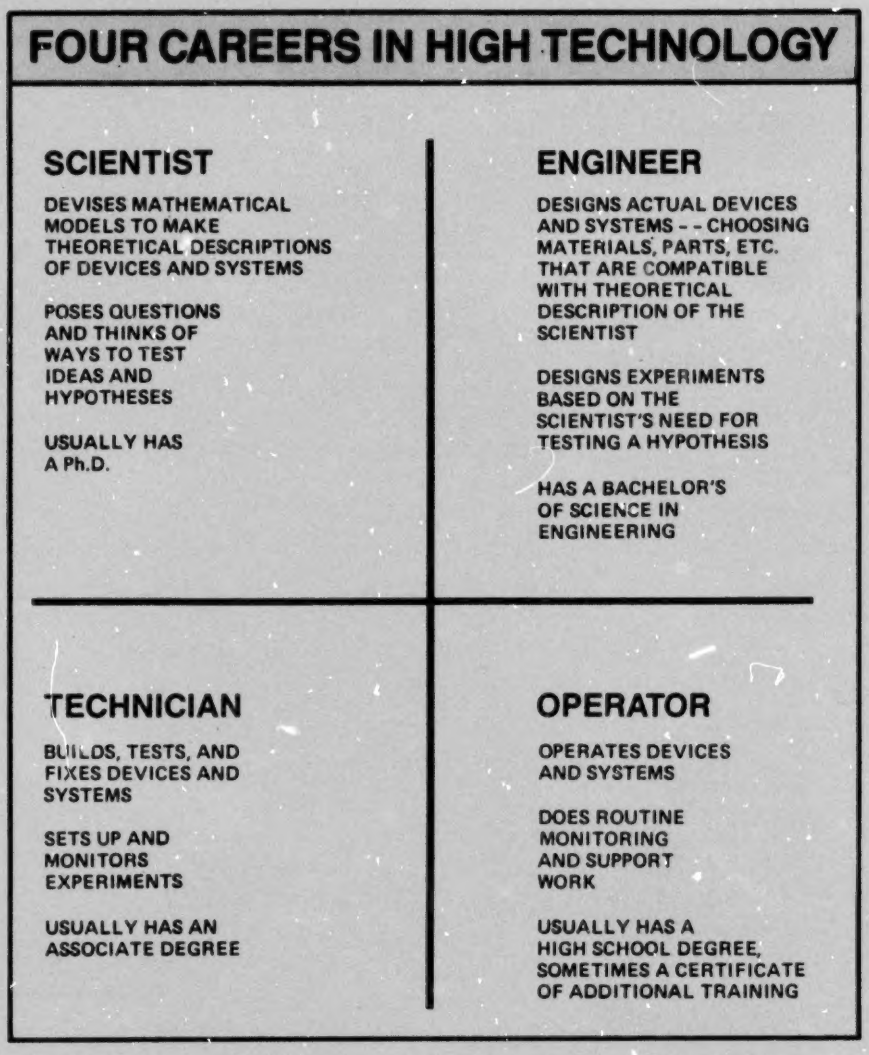
LEVELS OF PREPARATION

Four levels of technical job classifications can be identified in most high-technology industries: scientists, engineers, technologists and technicians, and operators and assemblers. In most workplaces, each of these classifications is subdivided into several "grades" or job levels. Personnel usually fit into one of the four main classifications according to basic educational background and are promoted within that classification by virtue of work experience, supplementary educational experience, recognized merit, patents and publications, and so forth.

SCIENTISTS

As mentioned in Chapter I, high-technology industries are characterized by a comparatively high percentage of scientists and engineers. Scientists are generally involved in theoretical work: posing questions, devising mathematical models for physical phenomena, constructing and testing hypotheses. Their ultimate goal is knowledge of the physical world gained through observation, study, and experimentation. Many scientists are also concerned with new application of this knowledge; they may contribute to the development of new products, the location of natural resources, or the improvement of manufacturing processes. Scientists almost always have a doctoral degree. Their educational path usually begins with a strong academic orientation in high school--with an emphasis on math and science--followed by the earning of a Bachelor of Science degree in the preferred major, and the pursuit of the doctoral degree in a recognized graduate department. In some cases, students may pursue graduate studies in a branch of science other

than their undergraduate major, but those who do so must have adequate background (as demonstrated by undergraduate credits and/or a high achievement test score) in the field of graduate study.


FOUR CAREERS IN HIGH TECHNOLOGY
SCIENTIST
DEVISES MATHEMATICAL MODELS TO MAKE THEORETICAL DESCRIPTIONS OF DEVICES AND SYSTEMS
POSES QUESTIONS AND THINKS OF WAYS TO TEST IDEAS AND HYPOTHESES
USUALLY HAS A Ph.D.
ENGINEER
DESIGNS ACTUAL DEVICES AND SYSTEMS - - CHOOSING MATERIALS, PARTS, ETC. THAT ARE COMPATIBLE WITH THEORETICAL DESCRIPTION OF THE SCIENTIST
DESIGNS EXPERIMENTS BASED ON THE SCIENTIST'S NEED FOR TESTING A HYPOTHESIS
HAS A BACHELOR'S OF SCIENCE IN ENGINEERING
TECHNICIAN
BUILDS, TESTS, AND FIXES DEVICES AND SYSTEMS
SETS UP AND MONITORS EXPERIMENTS
USUALLY HAS AN ASSOCIATE DEGREE
OPERATOR
OPERATES DEVICES AND SYSTEMS
DOES ROUTINE MONITORING AND SUPPORT WORK
USUALLY HAS A HIGH SCHOOL DEGREE, SOMETIMES A CERTIFICATE OF ADDITIONAL TRAINING

ENGINEERS

Applying the theories and principles of science and mathematics to practical technical problems is the work of the engineer. Many engineers are involved in the design of systems, devices, structures, or experiments. Others work in the testing, production, operation, or maintenance of systems that have already been designed. In recent years, many engineers have worked with scientists on the leading edge of technological innovation, and engineers have been responsible for many of the notable technological

breakthroughs of this century. The career path of engineers usually begins with the academic track in high school--with an emphasis on math and science. In college, they may major in one of the many specialty areas of engineering. During the first two years of undergraduate studies they usually study basic sciences, math, introductory engineering and selected courses in the humanities. During the last two years, most courses taken are in engineering. Many engineers go on to earn a master's degree at some stage of their careers, because the advanced degree provides an opportunity to learn a new technology and to gain promotions. Most engineers also pass an examination in their field of practice, thereby earning certification as a professional engineer.

TECHNOLOGISTS AND TECHNICIANS

Technologists and technicians provide technical assistance for activities in the engineering, scientific, computer, medical, and similar professional fields. Technologists and technicians generally focus on the practical aspects of a given project; using testing and measuring equipment in a laboratory or industrial shop, planning and carrying out the installation, maintenance, and repair of equipment, ensuring the accuracy of experiments, the quality of products, or the efficiency of operations.

Technologists are usually so named because their position requires a four-year technology degree; but the distinction between technologists and technicians may vary with the field of study, the state and regional accreditation criteria, and the employer's definition. Some schools have a four-year program leading to degrees in engineering technology (as distinguished from a Bachelor of Engineering). Graduates of these Bachelor of Technology programs may obtain some of the same type of entry-level positions as professional engineering school graduates, but they are regarded by many employers as having skills between those of a technician and an engineer. Other technologists have bachelor's degrees in math or one of the sciences. In a few cases, the term technologist is traditionally used to designate personnel who provide technical assistance in a given field even though a four-year degree is not required. For example, an X-ray technologist is not required to have a four-year degree but has a higher skill level and greater experience than an X-ray technician.

Technician is the most widely used title for technical assistance personnel. Technicians perform day-to-day tasks required to carry out a project or to run an operation. By its nature, high technology dictates an expanded role for technicians, requiring that they actively solve problems, troubleshoot, and communicate rather than routinely or passively assemble and fix. Although technicians generally do not make policy decisions,

generate theories, or create new designs; they often play a key role in implementing policy decisions, carrying out experiments, and building prototype designs. Some technicians assume a great deal of responsibility: supervising others, keeping records, setting up and following through with maintenance and testing schedules, selecting equipment for purchase, and corresponding with vendors.

Technicians may enter the field in several ways. The most widely accepted way to become a technician is to obtain specialized training in a one- or two-year postsecondary school program. Such programs are offered by technical institutes, junior colleges, area vocational-technical schools, and a few private or proprietary training programs. These programs may last for one or two years, and graduates are usually awarded an associate degree or a certificate of accreditation. Entry into these programs almost always requires a high school diploma. Although postsecondary school training is considered the most direct route to a high-tech career, there are other ways to become a technician. Some industries provide on-the-job training, vendor training, or short-term classroom programs, especially for workers who may be displaced from other jobs within the company. Occasionally persons with college courses in engineering or science are hired as technicians; they may be especially good candidates for in-plant training, vendor training programs, or short courses offered by professional societies. Some technicians may have obtained the skills and knowledge of their vocation while in the military. Finally, a few people may find entry-level technician jobs after high school vocational training and subsequently learn on the job. However by specializing in high school and foregoing postsecondary training, these technicians may sacrifice the broad base that allows them occupational flexibility later on.

OPERATORS AND ASSEMBLERS

High technology has spawned many new jobs and changed many old jobs by the introduction of new equipment. Word processors, digital engine analyzers, data-base systems, physiological monitoring systems, and other types of automated machinery and instrumentation have generated a host of jobs for operators of such equipment. Operators must be able to use high-technology equipment efficiently but, generally speaking, they do not have to know how it works or how to fix it. Operators may have skills in an area not related to the "inner" workings of high-tech equipment. For example, word processor users may be highly skilled typists; they are trained to use the word processor efficiently and to solve problems at the keyboard, but they do not remove or alter the circuit boards that cause the word processor to function. Some types of automated machinery require routine, even daily,

maintenance and inspection, but the tender or operator of these machines does not have to know how to repair them.

As pointed out earlier, some positions titled "operator jobs" are in fact much more than that; they require intensive knowledge of systems operations. On the other hand, some employees titled as technicians are actually operators with relatively low skills.

Operators can usually be trained within a short time on the job or through a short-term class or workshop. Operators are often selected for training from among the existing workforce, because they are willing and able to learn a new skill and because they understand the former process (traditional machining, gas welding, etc.) thoroughly. For example, an office manager is not likely to send a poor typist for training in word processing. By contrast, a production supervisor is likely to select a competent machinist to oversee the operation of CNC machining centers. The preparation of operators often takes place in high school vocational courses. Students trained in the operation of high-tech equipment are naturally prime candidates for entry-level positions. The advantage of these students is that they can begin work immediately after high school without costly training. The major disadvantage is that operators are not generally able to change jobs laterally or vertically without further training. Operators often work with costly, sophisticated equipment; therefore, employers rarely hire people who lack a high school diploma for these jobs.

The assembly of high-technology equipment, especially electronics components, is often a low-skilled job. Electronics firms often hire assemblers at minimum wage. These jobs may require a high degree of manual dexterity but little skill or specialized knowledge. A high school diploma is desirable but not always necessary in these jobs.

FOUR KINDS OF HIGH-TECH CAREERS

How do the career fields of a scientist, engineer, technician and operator differ? We can answer this question, at least partially, by examining the activities and responsibilities of each in a common career field. Let us choose for our common work area the field of robotics--encompassing the design, building, installation and the operation of robots in the industrial workplace.

The **robotics scientist** would work generally in the design phase. The scientist would deal with problems such as state-of-the-art advances in artificial intelligence, that is, better "eyes" "hands" and "brains" for a new generation of robots. For example, a robotics scientist would design--on paper--the computer system, the optical and tactile sensors, and the control mechanisms for the new robot. The scientist would make all of the necessary mathematical calculations to ensure that the integrated systems would work together. The scientist might also talk with an engineer to make sure that the system "designed" on the blackboard or a pad of paper could in fact be built with existing computers, sensors, fiber optics, pneumatic devices and so on.

The **robotics engineer** would be responsible for taking the design laid out by the scientist and actually "building" the new robot. The engineer would identify precisely each of the parts needed, specifying such information as type of material, current limits, voltage limits, temperature limits, hardness, brittleness and so on. The engineer might be called upon to redesign several parts in some detail to ensure, for example, that they would fit together neatly in the arm of the robot. The robotics engineer would be responsible for ensuring that all of the designed parts remained "faithful" to the overall design specifications of the new robot. The robotics engineer would also predict the actual performance limits of the robot and design experiments to test these performance limits. Usually the engineer would consult--and discuss problems--with the scientist who designed the new robot system. At the same time the engineer would prepare a technician to assemble and test the robot once the individual parts were built and ready for assembly.

The **robotics technician**, working under the supervision of an engineer (or scientist), would perform the actual assembly of the final robot. The technician would work from drawings and would

use screwdrivers, soldering guns, pliers and wrenches in the assembly phase. The technician would test each component for performance specifications and--upon completion of the new robot system--would run the experiments outlined by the engineer to test the performance of the overall robot system. The technician would become familiar with all parts of the robot system and would know how they worked together. The technician would be able to "fine-tune" the robot performance for given tasks. In an industrial setting, a robotics technician would be able to assemble, disassemble, troubleshoot, repair and modify one or more robot systems. On occasion, the technician would provide important feedback to the engineer and the scientist--information that might lead to improvements in the redesign of existing robots or in the future design of entirely new robot systems.

The **robotics operator** generally runs or operates the robot system in a given workplace or industrial setting. A robotics operator works on the "outside" of the robot, while the technician, engineer and scientist--as we have seen--are all involved to varying degrees with the "inside" of the robot. The robotics operator becomes completely familiar with the operator manual and knows how to operate, maintain, recognize malfunctions, and perform simple repairs. The robotics operator is concerned with the real-time operation and routine maintenance--cleaning, lubrication and safety, for example--of the robot in a specified operation. The robotics operator is a skilled person who simply makes the robot operate as it was intended to for a given manufacturing operation.

Listing these high-technology job classifications in a particular order--scientist, engineer, technologist, technician, operator, assembler--implies a fixed hierarchy of skill levels and perhaps a corresponding hierarchy of salaries and responsibilities. In the real world of industry and research, such hierarchies may undergo multiple permutations. Engineers often become managers and executives. Highly skilled technicians also often command salaries that exceed those of college graduates without technical training. People with unique combinations of skills may gain a high degree of prestige and benefits unattainable to someone more specialized. Certain specialists may be in high demand for a few years and later become sought

after less enthusiastically. In recent years, industries have begun to experiment with new management styles, putting a greater emphasis on worker input and shared responsibility. Evidence suggests that job classifications and corresponding compensation may be changing in fundamental ways. For example, a major electronics firm is experimenting with a new way of classifying its employees in a system known as "Tri-Track." Tri-Track recognizes three basic types of occupations: theoretical design and research, people management, and machine management. The first category includes physicists and most engineers; the second includes management personnel, trainers, and personnel employees; and the third category is the technical workforce--certain types of engineers, technologists, technicians, operators and assembly workers. Within each category there is a continuum of responsibility, and persons at the highest skill and knowledge level of the continuum within each category may be similarly compensated. In this system, excellence is rewarded in several different ways, one of which is peer recognition. For example, it is recognized that physicists have spent many years acquiring the knowledge and methodology of their discipline and that relatively few people are able to synthesize information and project new ideas on such a level. For these abilities they received high peer recognition. High recognition is also accorded the manager who has shown excellence in leading and organizing people to accomplish established goals within the company. Where Tri-Track may be breaking new ground is in the third occupational category where high recognition (and monetary compensation) is given to the top-level technicians whose combined skills, knowledge and efficiency regularly save the company thousands of dollars.

Even as management styles change and job classifications shift, schooling will remain highly valued on the socioeconomic scale, and there will probably always be a certain degree of ranking that corresponds directly to the amount of schooling a person brings to the job. However, in a world that is increasingly reliant on technology, it is only logical that the "hands-on" skills required to keep technology afloat should be highly valued as well.

THE ROLE OF THE TECHNICIAN

Of all the careers in technology described here--scientist, engineer, technologist, technician, operator, and assembler--that of the technician is certainly undergoing a dramatic change in the wake of new technological achievements. For that reason, the role and the preparation of technicians are the focus of this guide. In most instances, the role of the technician falls between that of the vocational industrial craftsman and the professional engineer. This is a broad range and is ill-defined in practice, having gray areas at either end of the continuum and at many points in between. Perhaps the best way to define a technician is by a summary of the tasks performed and accompanying skills required.

TECHNICIAN'S TASKS

1. PERFORM TESTS ON MECHANICAL, HYDRAULIC, PNEUMATIC, ELECTRICAL, OR THERMAL COMPONENTS OR SYSTEMS; PREPARE APPROPRIATE TECHNICAL REPORTS COVERING THE TESTS.
2. OBTAIN, SELECT, COMPILE, AND USE TECHNICAL INFORMATION FROM PRECISE MEASURING AND RECORDING INSTRUMENTS.
3. ANALYZE AND INTERPRET INFORMATION OBTAINED FROM PRECISE MEASURING AND RECORDING INSTRUMENTS AND SPECIAL PROCEDURES AND TECHNIQUES.
4. PREPARE OR INTERPRET ENGINEERING DRAWINGS AND SKETCHES; WRITE DETAILED SPECIFICATIONS OR PROCEDURES FOR WORK.
5. DESIGN, HELP DEVELOP, OR MODIFY PRODUCTS, TECHNIQUES, AND APPLICATIONS IN INDUSTRIAL SETTINGS.
6. PLAN, SUPERVISE, OR ASSIST IN THE INSTALLATION AND INSPECTION OF COMPLEX SCIENTIFIC APPARATUS, EQUIPMENT, AND CONTROL SYSTEMS.
7. OPERATE, MAINTAIN, AND REPAIR COMPLEX APPARATUS AND EQUIPMENT WITH EXTENSIVE CONTROL SYSTEMS.
8. ADVISE, PLAN, AND ESTIMATE COSTS AS A FIELD REPRESENTATIVE OF A MANUFACTURER OR DISTRIBUTOR OF TECHNICAL APPARATUS, EQUIPMENT, SERVICES, AND/OR PRODUCTS.
9. APPLY KNOWLEDGE OF SCIENCE AND MATHEMATICS WHILE PROVIDING DIRECT TECHNICAL ASSISTANCE TO PHYSICAL SCIENTISTS OR ENGINEERS ENGAGED IN SCIENTIFIC RESEARCH AND EXPERIMENTATION.

SPECIAL ABILITIES AND SKILLS

To perform the tasks listed on the previous page, modern technicians must have the special abilities and skills described below:

1. Practical application and use of the basic principles, concepts, and laws of physics and technology.
2. Facility with mathematics; ability to use algebra and trigonometry as problem-solving tools. When needed, an understanding of higher mathematics--analytic geometry and some calculus--according to the requirements of the technology.
3. Facility and appropriate skills in the use of materials, processes, apparatus, procedures, equipment, methods, and techniques commonly used in the technology.
4. Knowledge of the field of specialization with an understanding of current applications of engineering or industrial processes in the field.
5. Communication skills that include the ability to record, analyze, interpret, synthesize, and transmit facts and ideas with objectivity--orally, graphically, and in writing.

The lists provided here are necessarily generic; more specific notions of the technician's role can be gained by examining several job factors: the institutional setting, the managerial organization, and the field of specialization. The information presented here in the form of job descriptions and anecdotal accounts reveals how each of these factors influences the role of the technician.

FIVE TECHNICIANS ON THE JOB--PERSONAL ACCOUNTS

Technicians are employed in a variety of settings; three of the most common are the production areas of industry; the sales and service branches of business and industry; and the research and development laboratories of government, industry and higher education. The following accounts provide insight into the role of the technician in these three areas.

Technicians who work in production areas face a unique set of problems in their work. One technician described her job in production as follows:

> "I work for a large company that makes, among other things, calculators. My job is the testing of integrated circuits for calculators. Although my background is in electronics, a lot of the work I do is mechanical, because the testing machine is electromechanical and part of my job is to keep it functioning properly. I'm hardly supervised at all, but we have production quotas, so I know what I have to do to keep up. The best part of my job, to be honest, is the money, which is good--that and the fact that at the end of the day when I go home, the job stays here. Once in a while there is some pressure, because my area is the bottleneck of production. The people who make these circuits give me a hard time about it, but if they did their jobs right in the first place, I wouldn't have so much work. But you have that kind of thing on every job. Eventually I'd like to move up, to be a supervising technician for this testing group, maybe, but that will probably be a while in coming."

Sales and service technicians confront yet another kind of challenge as described in the account below:

> "I really like my job. I work for a small company that manufactures kits for musical synthesizers. The president of the company is an electrical engineer. I'm the top technician here now, and I work with three other people that I like a lot...When we receive malfunctioning synthesizers, we test and troubleshoot. We get a considerable range of problems--some are easy to identify, but some are outrageous. When we figure out the problem, we assess the service hours and parts that are needed, if any, and write a letter to the customer. Another small group here does a lot of the actual repair. After two and a half years here, I've learned a lot about synthesizers, and I have a few ideas of my own about how to build them that I've talked over with (the president of the company). I think eventually I'll get to do some design work."

One technician was able to compare two employment experiences as a research and development technician--first for a major corporation and subsequently at a university research center.

> "I've worked in two research jobs--first for the research division of one of the the multi-national oil corporations and now for a major university. The main differences in these jobs have to do with the approach to research of the two institutions. In a profit-making industry, the work is very goal-oriented. Somewhere down the line there's a plan for a new plant, a new production process. At the university, they're mainly interested in gathering data. The more information generated, the better...There are other differences. Private industry seems more efficient in their use of money and staff time. At the company, money was more expendable--I could order whatever materials I felt were needed with no questions. Here at the university, my time is more expendable. If I can make something myself instead of buying it, I do--even if it means a lot of hours expended. Partly for that reason, here I feel underutilized. I do more menial work than I did in the company...The supervision is very different. In the company, my supervisors would actually discuss strategies for moving up with me. They encouraged me to apply for patents on my designs (partly for the sake of the company, of course) and to go as far as my potential would take me. Here I have to be careful about not stepping on somebody's toes. People are a little bit more reluctant to let a technician do design work; there's a feeling that if you were smart enough to design, you would have gone to college. I never got that in industry. On the other hand, I recently got a good motivator here at the university; my name is going to be one of three on a paper to be presented at an engineering conference. Now that makes the job exciting."

Technicians may be supervised in a variety of ways. Technicians often work closely with and are supervised by engineering and science professionals or managerial personnel. Frequently, they are part of a team working on a given project or operation. Some technicians work relatively independently on a day-to-day basis, although in a cooperative role. One technician described his relationship to a supervising physicist in a research setting in the following way:

> "I consult with him when I'm uncertain about how he wants something done, when I have a special problem, or when quality is a matter of very close judgment; but I think through procedures and problems carefully before I consult him. And I make my own judgment--based on my

> experience on the job--as often as possible. I do communicate with him and sometimes other people communicate with him through me, but I feel that I'm doing my job well when I don't need to consult him very often. Everything is getting done; he doesn't have to think about a lot of details, because I take care of them. I never have to ask for something to do; I anticipate problems and set my own deadlines according to project needs."

Another technician, who works as part of a team building state-of-the-art lasers, described a very different work situation with regard to supervision.

> "The supervising technician is in constant communication with the team members. She's really more of a team leader than a "boss"; her supervisor, an engineer, has more of a "boss" role, but we rarely see him here in the lab. It isn't unusual to have parts of the design changed for certain applications, so we have to keep in touch at all times. The atmosphere here is loose in a way, I guess, because we talk and joke a lot--including with our supervisor. On the other hand, we're always working on the project. We talk about it over lunch; we work late to meet deadlines, we go to parties and talk shop. The supervisor makes some of the judgment calls, gives us design information obtained from the engineers, and so forth. She also collects our feedback and talks to the engineers about it."

TECHNICIAN LEVELS OR GRADES

In most institutions of industry and government, technicians' jobs are graded by the skill and experience level required, with job responsibilities and salaries ranging accordingly. For example, a large communications firm listed four levels of technicians with postsecondary training but without college degrees:

- Lab technician (entry-level with no experience but possessing postsecondary technical training, usually in electronics).
- Senior lab technician (postsecondary training plus experience).
- Lab specialist (postsecondary training plus experience in a given area gained through additional specialized training on the job or through short courses).
- Senior lab specialist (postsecondary training and experience plus expertise in a specialty area).

In addition to these skilled jobs, the firm hires (in greater numbers) unskilled persons in other categories; these workers are known as "operatives" and "assemblers." They construct and assemble electronic components under explicit instructions and in a routine manner. In this firm, the title "Technical Staff Assistant" is ordinarily associated with employees who have a four-year degree.

A large research facility at a state university hires technicians at five levels: Technical Staff Assistants I through V. Technical Staff Assistants I perform limited or semiskilled work taking on a major portion of the laboratory's heavy lifting jobs, transporting equipment, assembling equipment under supervision, and performing routine mechanical maintenance tasks such as oiling machinery. Technicians in this category are required to have a high school diploma only. By contrast, Technical Staff Assistants V perform highly skilled technical support work. They fabricate experimental devices according to specifications and may even design simple components. They calibrate, test, maintain, and operate experimental apparatus, perform tests using such equipment, and record results. These technicians are so classified because they have postsecondary education in a specialized field such as electronics or laser technology as well as experience in research and development.

SPECIALTY AREAS

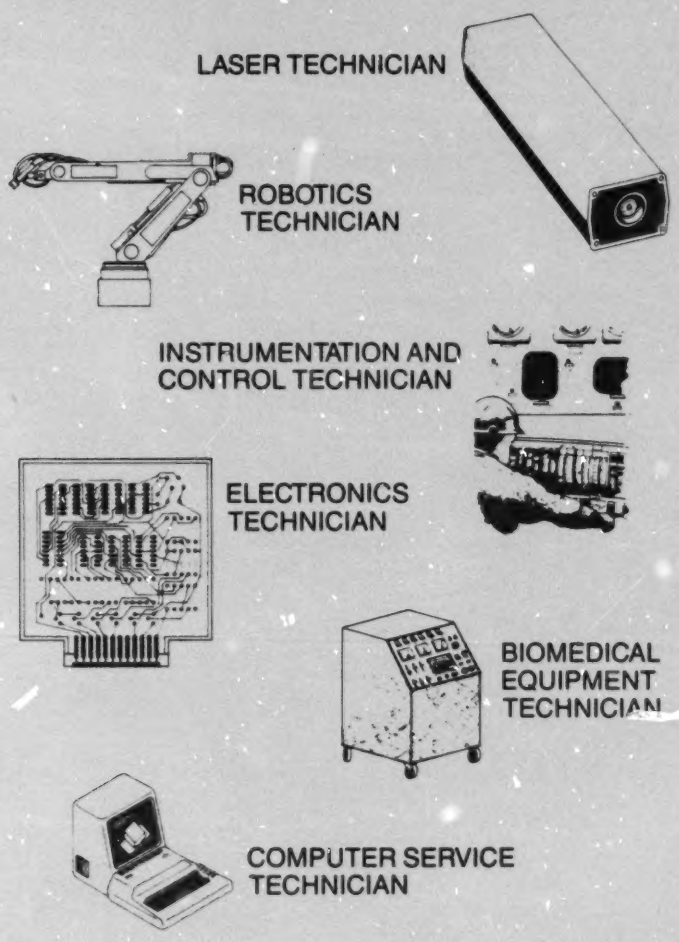
Finally, the technician's job is defined by the chosen field of specialization. The following brief job descriptions provide a glimpse of the breadth of choices:

Laser Technician--Troubleshoots and repairs laser systems, fabricates and assembles components for laser systems; aligns optical systems for lasers; performs tests and measurements of laser output characteristics; uses various optical equipment including interferometers, spectrometers, monochromators, spectrophotometers; operates and calibrates photodetectors, photomultipliers, optical power meters, and calorimeters; produces and reconstructs holograms.

Senior Electronics Technician--Performs responsible technical duties related to the development and evaluation of complex circuits and systems for product application and product engineering support of production. Directs and trains subordinate personnel as required. Requirements: Two-year degree in electronics plus two to three years experience.

Instrumentation and Control Technician--Specializes in the development, installation, operation, maintenance, and repair of instruments and systems that measure, indicate, record, analyze, and/or control a variety of scientific and industrial processes (distance, temperature, radiation, velocity, pressure, etc.). May assist in the design of these devices, build experimental models of instruments, evaluate their performance, adjust or repair defective instruments, and operate and monitor these systems.

DIFFERENT TYPES OF TECHNICIANS



Biomedical Equipment Technician--Constructs, adapts, maintains, repairs various types of medical electronic equipment used to diagnose and treat disease. Assists medical staff in using equipment and advises supervisors on equipment needs, recommending types, models, and manufacturers. May assist practitioners, nurses, and researchers in conducting tests and procedures. Instructs medical staff on the proper use of various types of equipment. May be involved in supervision of equipment control, preventive maintenance and safety programs. Must be knowledgeable about the theory of operation, underlying physiological principles, and the practical, safe application of biomedical equipment.

Automated-Manufacturing (Robotics) Technician--Requires an electromechanical technician with strong diagnostic skills in hardware, fully familiar with software and firmware (prepackaged software). Must be able to operate, test, diagnose, troubleshoot, modify, repair, and adapt appropriate systems and system components. Works under minimal supervision of an engineer or senior technician as a member of a team; may assist other technicians. Must have knowledge of manual processes. Must know and routinely use appropriate safety procedures.

Computer Service Technician--Services computer systems (mainframes, microprocessors, and peripherals) to keep them operating efficiently. Routinely adjusts, oils, and cleans electromechanical parts, and checks electronic equipment for defective components or circuits. Troubleshoots and repairs computers, using test equipment such as voltmeters, ohmmeters, and oscilloscopes. May repair faulty circuits, solder broken connections, and repair mechanical parts, as needed. Assists in installation of new equipment. Keeps service records.

CHAPTER III. VOCATIONAL EDUCATION AND HIGH TECHNOLOGY

IN THIS CHAPTER ...

- Rationale for pretechnical studies and articulated programs.
- Discussion of the polarization between vocational and academic programs.
- Education for technicians at the secondary level.
- Specialization at the postsecondary level.

Nationwide, vocational educators are exploring ways to respond to the needs of the high-technology revolution. The ideal education for the technical workforce of the future is a matter for continuing discussion, and no single model is appropriate for every situation. The path of educational reform is strewn with "ideal" curricula that were implemented abruptly without regard for the strengths or the histories of existing programs. Curriculum changes are best approached not in a superimposing way, but investigatively. With respect for the tried-and-true, educators should seek to retain the best of existing programs while assertively implementing changes to meet current needs and higher standards.

PREPARATION FOR HIGH-TECH CAREERS

Many technicians have a background that can best be described as hybrid. In the early years of laser technology, electronics technicians were "cross-trained" in optical fundamentals. Some assemblers have recently left the shop floor for electronics training in order to return as robotics technicians. Science majors weary of academia have entered technical training programs in order to become more readily employable. Automotive mechanics, welders, and machinists seeking a new career challenge and increased job security have entered specialty training in high-technology areas. Many women have retrained for high-tech careers in recent years, often leaving traditional, low-paying jobs in favor of the increased challenge and high pay associated with technical fields. In short, the career paths of technicians do not fall neatly within traditional vocational or academic tracks. The reasons that high-tech technicians have so often come to their careers by circuitous routes--usually involving education, skills training and experience in two or more fields--lie in the nature of high-technology systems.

The devices and systems of high technology--automated, instrumented, and computerized--require special competencies for production, testing, installation, and maintenance. To perform such functions, technical personnel need to understand systems--combinations of electrical, electronic, mechanical, fluidic, pneumatic, optical, and thermal applications.

Many high-technology occupations have a universal requirement for an individual with ability to transfer knowledge from one set of tools and materials to another set of tools and materials. Often this transfer includes changes in energy forms. The skills of high technology are acquired, therefore, by developing an understanding of the physical sciences and their applications rather than by becoming proficient in a trade or craft or exclusively through academic study. This requirement calls for new dimensions in the instructional program. The lengthy and meandering career development of many of today's technicians is a costly, inefficient method of gaining the skills of high technology. Given the increasing demand for qualified technicians, the public school system must assume a greater role in the education of the technical workforce. Many of the nation's schools have already begun restructuring their curriculum to meet the critical need for technological literacy as well as for the specific preparation of technicians.

Educational curricula for technicians in high-technology fields have been developed with a "systems" orientation and a broad base of applied physics. With such a program of instruction, the key elements of technology--electricity, mechanics, fluidics, and thermal principles--are presented as analogous rather than as isolated, independent phenomena. Basic competencies in science, mathematics, and communications (including computer basics), as well as a core of technical fundamentals, form the foundation for continuing study in the specialty areas. Offered in secondary school, this foundation can also provide an adequate basis for employment immediately after graduation, although employees without postsecondary training or specialty skills are usually hired as operators or technicians at the lowest entry level.

(PRE)HIGH-TECH STUDIES AND ARTICULATION

The nature of emerging jobs in high technology is causing some vocational educators to re-examine the structure of existing vocational programs. Although some high-tech training programs can be developed fully at the secondary level, the prerequisite knowledge and skills for many high-tech jobs seem to call for a different approach. For these jobs, an articulated program with the community college or technical institute can best fulfill training requirements.

While coordination between secondary and postsecondary vocational programs is not a new idea, neither is it a widely practiced one. The concept of articulation has been discussed frequently in recent years--articulation being the planned process within an educational system that allows students to move from one level of schooling to another without duplication of course work. Linked to competency-based education, articulation is seen as a means of increasing the effectiveness and accountability of vocational-technical programs while reducing costs and duplication of effort.

The postsecondary school must define the entry and exit levels of its technician training programs and, with the help of the secondary schools and industry, develop the necessary prerequisites. These prerequisites can then be translated into a set of courses and work experiences on which the secondary program is built; these prerequisites may be identified as the "pretechnical" preparation, analogous to the college preparatory programs in most comprehensive high schools. In the two-year pretechnical program the practical applications of math, physics, language skills, computer literacy, and the introduction to technologies are stressed. These concepts are applied in the existing vocational education program, which is modified to incorporate the pretechnical program. The postsecondary programs which follow would focus on the technical specialization of the chosen occupation. The articulated relationship between the two programs would carry the student from a pretechnical level in the high school program to a job-ready, advanced skill level upon graduation from the postsecondary institution. The progressive sharing of related basic skills and specialty training would presumably take place in a two-year secondary plus two-year postsecondary sequence and hence has been referred to as a "2+2" program.

Attempts are already being made to implement 2+2 programs in several places around the country. One example of such a program is the Pretech Program currently offered by the Richmond County Board of Education in Augusta, Georgia. Pretech in Augusta is a curriculum path designed to prepare students for entry into either a four-year program leading to a bachelor's degree in engineering or into a two-year high-technology associate's degree program.

The concept of articulation is a departure from some of the basic tenets of current vocational programs. To determine how to implement a pretechnical studies program, one needs to examine certain features of existing programs.

THE POLARIZATION BETWEEN VOCATIONAL AND ACADEMIC APPROACHES

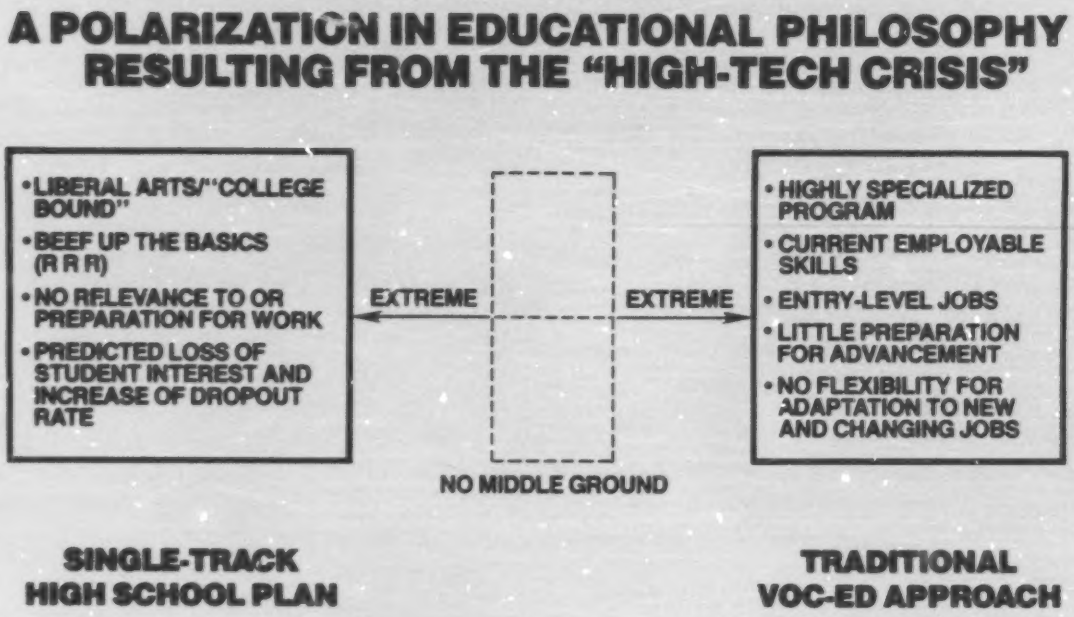
Existing vocational programs in most secondary schools have as their goal the immediate employability of graduating students. Throughout the 60s and 70s the emphasis has been on specialized programs that lead to current employable skills for entry-level jobs. The inherent strengths of these programs have been rooted in the employability goal. Students of vocational programs have been able to easily perceive the relevance of their schoolwork to the world at large and to their futures in particular. The hands-on learning activities of the vocational classroom have proved intrinsically interesting to students often decidedly uninterested in academic studies. In addition, what students learn in vocational classes is often immediately useful in their part-time jobs and at home. As a result of the relevance, enjoyment and usefulness of the vocational curriculum, many students on the verge of dropping out of school have remained to complete voc-ed training. Current vocational programs have graduated thousands of students into successful careers.

However, most existing voc-ed programs do not seem to provide an ideal preparation for high-technology careers. Voc-ed programs often teach a narrow specialization. Students learn skills that may become obsolete quickly, and they are not provided with a foundation for strengthening the basic skills that would allow them to retrain to move laterally or vertically into another job. Competencies and curricula are often "equipment-based" rather than "knowledge- or competency-based," i.e., based upon broad technical principles. Serious problems can arise when students are learning on equipment that is already going out of general use in industry. Voc-ed curricula sometimes tend to be fragmented with each teacher "doing his or her own thing" without a perspective on the continuity of students' education. (Teachers may reason that the job-relatedness of specialty teaching precludes the need for a unified direction.)

Finally, vocational programs have been considerably hindered in their effectiveness by the poor image of vocational students as "problem cases" or low achievers. Ironically, the reduction of the dropout rate that can be credited to many vocational programs may have worked against their success. As some school personnel have perceived the voc-ed track as a "last-hope" option for troubled and troubling students, increasing numbers of these students have been directed to voc-ed, rendering it a less attractive option for motivated students. Vocational programs must contend as well with the academic bias against those who work with their hands.

At its most extreme, the polarization between the voc-ed approach to education and the academic orientation is so great that it is difficult to see a middle ground. The liberal arts focus is almost exclusively on the

college-bound who often have little orientation to the world of work. The basics of the liberal arts education have traditionally been the three Rs, and although social studies has integrated nicely with the basics, science


A POLARIZATION IN EDUCATIONAL PHILOSOPHY RESULTING FROM THE "HIGH-TECH CRISIS"
•LIBERAL ARTS/"COLLEGE BOUND"
•BEEF UP THE BASICS (R R R)
•NO RELEVANCE TO OR PREPARATION FOR WORK
•PREDICTED LOSS OF STUDENT INTEREST AND INCREASE OF DROPOUT RATE
EXTREME
EXTREME
•HIGHLY SPECIALIZED PROGRAM
•CURRENT EMPLOYABLE SKILLS
•ENTRY-LEVEL JOBS
•LITTLE PREPARATION FOR ADVANCEMENT
•NO FLEXIBILITY FOR ADAPTATION TO NEW AND CHANGING JOBS
NO MIDDLE GROUND
SINGLE-TRACK HIGH SCHOOL PLAN
TRADITIONAL VOC-ED APPROACH

has often been considered something of an anomaly--requiring special equipment to teach, involving unfamiliar concepts that inconveniently expand every few years. By high school, students often perceive math and science as the domain of a few academically talented people. The sciences taught as part of the academic track are presented on an abstract basis; teachers often emphasize the history of scientific theory and derivation of principles rather than current applications of scientific principles. Predictably, many students who are job-oriented by virtue of their parents' thinking as well as those who are alienated from academia for other reasons rarely take high school physics, chemistry or advanced math.

The tendency of the schools has been to design all higher math and science studies for the preprofessional student. Vocational students are exempted early in their secondary schooling from opportunities to develop math and science skills; attempts to motivate them to do so cease in junior high, if not before, and they are directed to specialized job training. The point is not that these students should be pointed to the nearest physics lab instead of receiving job training, it is rather that the focus of mathematics, science, and technology education must be expanded from only the preprofessional student to include all students. The National Science Board Commission recommends in its 1983 report that "schools should provide

opportunities for their students to develop the mathematical and scientific skills to the limits of their abilities and should offer appropriate sequences of courses for students at various levels of ability."[29]

If the polarization of goals in vocational and college-bound studies will not serve the vocational student well in the coming decades, the academic student is also likely to be shortchanged under the current system. Preprofessional students tend to be those who adjust easily to academic life and who accept the hierarchy and rules of educational institutions. After moving through these institutions for sixteen years or more, they go suddenly and sometimes with a rude awakening into the "real world." Their previous experience has prepared them to function effectively in the academic environment, and less attention has been given to the eventual goal of a job and life after college. In short, academic as well as vocational students need career education.

Students cannot be expected to make good career decisions without adequate information. And, directly or indirectly, most students begin to narrow their career decisions significantly by their first year in high school. For students interested in high-tech careers, lack of information is a particular disadvantage. Many students now receive their primary orientation to high technology from movies, television, and the video arcade. Most educators would agree that those are fine ways to become interested in a high-tech career, but they provide little of the needed realistic exploration of specific fields.

The middle school has been suggested as an appropriate level at which to introduce exploration of industry and its technologies. An orientation to industrial systems--communication, energy use, production, and transportation--would continue throughout tenth grade, at which point the student could presumably make a commitment to a pretechnical studies program such as the one discussed in the next section.

[29] The National Science Board Commission on Precollege Education in Mathematics, Science, and Technology. Educating Americans for the 21st Century. Washington, DC: National Science Foundation. Sept. 1983.

EDUCATION FOR TECHNICIANS AT THE SECONDARY LEVEL

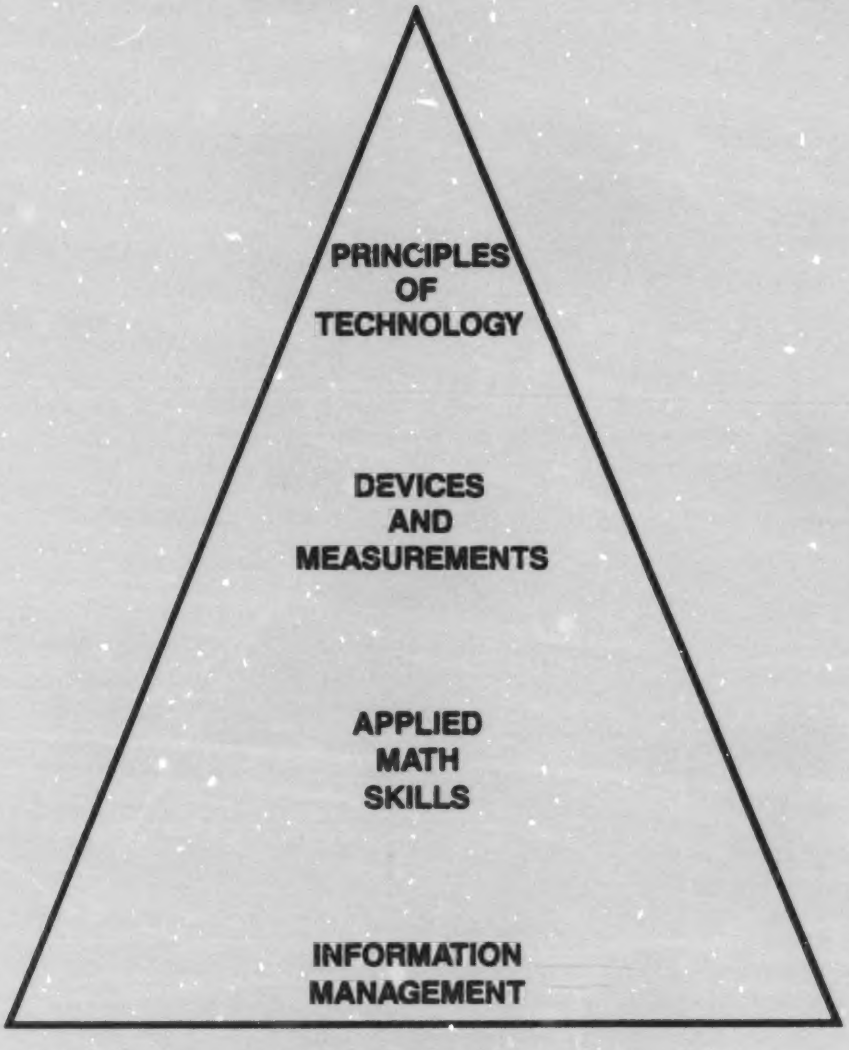
The vocational student, having taken part in the appropriate career education activities in earlier grades, is presumed to have narrowed his or her career choice by the end of grade 10. Such a student would enter the pretechnical studies program at the beginning of grade 11. It is estimated that part of the pretechnical student's curriculum in grades 11 and 12 would be devoted to a core of vocational/technical fundamentals. The vo-tech core would consist of four components:

- Principles of Technology--Technical principles that do not become obsolete taught through laboratory experiences that emphasize current applications.
- Devices and Measurements--Familiarization with scales, rules, meters and other devices of measurement used in all vocational areas from allied health to office occupations. This course is recommended not only for pretechnical students, but also for most vocational students.
- Applied Math Skills--The application of arithmetic and mathematics to a variety of practical problems.
- Information Management--This course would include report-writing, recordkeeping, logbook skills, simple graphics, memo-writing and other kinds of technical communication skills that are required of technicians. Under this heading are included the skills of keyboarding and computer literacy; these skills contribute to the student's ability to convey, compile, and store work-related information.

The technical core components, as described above, do not correspond directly to credit courses, and they would not be uniformly weighted. The Principles of Technology is considered the most significant and largest part of the core and might be allotted as much as two full credits; Devices and Measurements, Applied Math, and Information Management could be taught as half-credit courses and, in some cases, might fall within the boundaries of other courses. As indicated, the technical core is not intended to comprise all of the pretechnical vocational student's curriculum; current employable skills would continue to be a substantial portion of the student's preparation.

The heart of the technical core is the course, Principles of Technology, in which students would learn about:

- The underlying concepts and principles of force, work, rate, momentum, resistance, power, energy, force transformers, energy convertors, transducers, vibrations, time constants and radiation.
- The analogous behavior of these concepts and principles in mechanical, thermal, electrical, and fluidal systems.
- How these concepts and principles govern the behavior of technological equipment and devices.



SUGGESTED CORE COURSES

A consortium of state agencies and provinces in North America has already begun supporting the development of the Principles of Technology course. The Center for Occupational Research and Development (CORD) and the Agency for Instructional Technology (AIT) are now developing draft copies of course materials for pilot-testing by participating agencies. Pilot testing is expected to begin by September of 1984. The course is designed to meet the following conditions:

1. Existing voc-ed teachers must be able to teach the new curriculum with a minimum of additional training.

2. The new curriculum must utilize existing classroom and shop facilities and must not require costly expenditures for physical plant modifications or specialized lab equipment.
3. The sequence of instruction must be composed of relatively independent modules that allow instruction to be scheduled for two full years, one year, or whatever amount of time can be made available.
4. The new curriculum should provide students with the practical, hands-on learning experiences that have been the unique strength of vocational education instruction.
5. The course should strengthen students' mathematics and problem-solving skills as they relate to technical careers.

A more complete description of the Principles of Technology course now under development is included in Appendix A of this guide.

The proposed laboratory-based, systems-oriented curriculum would preserve the unique strengths of the traditional voc-ed curriculum while adding important fundamentals to the instructional program. Such a technical core would be effective in the following areas:

- Generation of student interest.
- Retention of technical principles by students.
- Relevance and applicability of content to the prospective technician's field of work.
- Immediate employability of high school graduates maintained as an option.

Pretechnical students would graduate with a foundation with which to enter the job market upon graduation. This foundation would facilitate their on-the-job training in high-tech industries, and it would help speed their retraining as equipment and procedures change in the future. Students would be equally well-prepared to enter postsecondary training in a high-tech specialty area such as laser/electro-optics, robotics, biomedical equipment technology, and so forth.

The Principles of Technology and the entire technical core are flexible and can be quantified in course credits with regard for the demands of the other vocational skills courses, state diploma requirements, and locally specified credit requirements. The curriculum model outlined in Appendix B of this guide is intended to help the counselor visualize how such a curriculum may be modeled in the future.

SPECIALIZATION AT THE POSTSECONDARY LEVEL

The graduate of a pretechnical studies program such as the one described in the previous section would be well-prepared to enter a training program in a specialty area, such as the ones listed below:

- Laser/Electro-Optics
- Computer Technology
- Microelectronics/Telecommunications
- Nondestructive Testing
- Instrumentation and Control
- Robotics
- Automated Manufacturing
- Energy Conservation and Use
- Computer-Assisted Design
- Biomedical Electronics

In postsecondary school, these students would build on their knowledge of technical fundamentals, taking courses such as electricity and electronics; electronic, mechanical, and electromechanical devices, circuit analysis, graphics, properties of materials, heating and cooling, computer applications and programming, and manufacturing processes. Besides these general technical courses, students would focus on six or more specialty courses in their chosen field--e.g., lasers, robotics, biomedical equipment, and so forth.

CHAPTER IV. COUNSELING IN THE HIGH-TECH ERA

IN THIS CHAPTER ...

- Current concepts of career planning.
- Activities for career guidance in high technology.
- Future trends that are affecting the content of guidance programs and their implications for career guidance.
- Computer-based career information systems and their impact on the counseling field.

The high-technology era introduces particular challenges for guidance and counseling professionals. Because a majority of counseling efforts are directed toward helping people plan and make decisions for the future, counselors need to be aware of future occupational changes and employment trends. However, the counselor's role goes far beyond the dispensing of career information. The counselor introduces students to decision-making skills that will enhance their capabilities to respond to change throughout their lives. In the fast-changing high-tech era, these skills are increasingly important.

CURRENT CONCEPTS OF CAREER GUIDANCE

Underlying the current concept of career guidance are the notions of free choice and entitlement. "The cornerstone of contemporary career scholarship and practice is the emphasis on free choice in occupational selection."[30] In this country the assumption is that occupational horizons should not be determined by socioeconomic or cultural background or by stereotyping based on sex, race or handicapping condition. Furthermore, the change in work attitudes is such that many people expect not only a job, but a good job--one that is likely to be satisfying and rewarding. Such expectations for job satisfaction rely heavily on informed choice involving "the deliberate assessment of available options."[31]

[30] Marilyn Jacobson and Barbara Grabowski. "Computerized System of Career Information and Guidance: A State of the Art," Journal of Educational Technology Systems. Vol. 15, No. 4. Jan. 1983.

[31] Ibid.

The evolution of career planning involves the combined notions of individual choice and information gathering. At one time, career choice was considered almost independently of marketplace needs. Young people underwent testing passively, and their interests and aptitudes were assessed and interpreted for them. Given the test results, which were expected to remain viable for a lifetime, they were considered free to choose an appropriate career.

Another approach to career planning has been to provide students with an abundance of information about how to gain entry into the field of choice but with relatively little information about how to choose that field. In this "method" of career guidance, young people are encouraged to go for the "sure thing," especially as dictated by recent marketplace trends. This approach (not generally espoused by guidance professionals) has resulted in the flocking of young people to professional schools of law, business, and medicine; in the vocational field students have been directed en masse to machine shop and electronics. The most extreme version of this method of career planning was exemplified by the businessman in the film The Graduate who reduced his "career guidance" for the young hero of the movie to one word--"plastics."

The concept of career planning that has emerged in recent years is a reasoned blend of former approaches. Students are encouraged to identify their own skills, preferences, work values, and aptitudes with the aid of assessment instruments (tests) and through dialogue with a counselor, group counseling activities, or computer interaction. Students are then encouraged to match these skills with labor market information and a knowledge of career preparation requirements. Particular attention has been taken to help the student overcome race and sex stereotyping so that career decisions are free of bias. The assessment and decision-making aspects of career planning prepare students for similar processes throughout their lifetimes. At the same time, the current fluid nature of work and careers brought about by high technology has made access to current, accurate labor market information increasingly important.

In summary, counseling professionals are working to help students develop educational and career decision-making skills that will serve them throughout their lives. Students are taught how to obtain career information; to relate career options to their individual aptitudes, interests and personal characteristics; to relate different subjects to skills and knowledge required for specific occupations; and to perform other activities to increase their self-awareness and career awareness.

ACTIVITIES FOR CAREER GUIDANCE IN HIGH TECHNOLOGY

Because high-technology careers are relatively new and undergo frequent changes, career guidance for high-technology fields presents a special challenge for counselors. Information about high-technology careers is not as easy to locate and must be updated more frequently than information about more traditional and stable career fields. Furthermore, students are unlikely to have a vivid idea of the actual tasks and environments of high-tech occupations. As a result, they are not aware of the connection between their present interests or their school coursework and the skills and knowledge required in a high-tech career. The counselor has to make special efforts to bring that connection to light for the student.

The counselor's major effort in the area of high-technology career guidance must be to establish strong working relationships with high-technology firms and research institutions. Through ongoing relationships with representatives from business and industry, the counselor ensures the input of career information from the workplace to the school and provides students with opportunities for experiential learning about high-tech careers. More information about obtaining sources from high-tech companies and company representatives is included in Chapter V of this guide. These resources should aid the counselor in implementing the activities listed in the following pages.[32]

[32] The career guidance activities that follow are keyed to objectives listed in the Guidance Program Manual of the Maryland State Department of Education, and performance objectives 1.1 and 1.2 are taken from a draft of the recently completed study, Post High School Transition: A Planning Guide for Educational and Job Placement prepared for the Maryland State Department of Education by Research for Better Schools, Inc., in Philadelphia, PA.

OBJECTIVE 1: Students shall comprehend their aptitudes, interests and experiences as related to their own career development.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
1.1 Students shall identify their own personal interests.	Guide students in discussing and interpreting interest inventory results. Review with students school and extracurricular activities and personal and work experiences. Have them develop a profile or summary of interests.
1.2 Students shall identify their strengths and weaknesses based on school performance and work experiences.	Have students complete a chart that identifies courses taken and grades or performance evaluation. Help students review employer evaluations of work experiences.
1.3 Students shall identify their strengths and weaknesses based on experiences which they may or may not identify as "work," and for which they may or may not get paid.	Provide students with a form or worksheet with which to evaluate such experiences. Examples of such activities are fixing the lawn mower or the family car, playing chess, building model planes, collecting coins, mediating family disputes, etc. Students should go beyond the activities in 1.1 to evaluate the ease and ability with which they accomplish these daily activities.
1.4 Students shall solicit feedback on their strengths and weaknesses from peers, family members, school personnel and other significant persons.	Provide students with an "interview sheet" for such solicitations; include space for the students' comment on the responses of others.

1.5	Students shall relate their personal interests and abilities to occupational opportunities.	Invite several high-technology technicians to participate in a panel discussion about the nature of their jobs and the ideal preparation for them. Have a moderator/recorder present the panelists with questions concerning their job skills, background knowledge, personal likes and dislikes about their careers, etc. Have the moderator record key answers for the students to see. Ask the technicians to describe their past education and future career paths.

OBJECTIVE 2: Students shall apply the steps of decision-making to any situation.

	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
2.1	Students will demonstrate the use of a decision-making process.	Teach an instructional unit that gives students specific steps to follow in any decision-making process: (1) Identification of problem or opportunity to choose, (2) research and brainstorming of possible options, (3) tracing of possible outcomes of various options, (4) establishing personal priorities, (5) weighing of outcomes against personal interests, abilities, and values, (6) making a decision. Ask students to provide a real or hypothetical decision involving these steps.
2.2.2	Students will identify and weigh the advantages and disadvantages of a given career option.	Provide students with sets of cards in two colors on which to write the advantages and disadvantages of a given career choice. (For vo-tech students, a possible example would be the option to go to work immediately after high school instead of seeking postsecondary training.) Then ask them to compare the two sets of cards, to identify factors that may belong in both sets of cards and to order the cards according to the advantages and disadvantages they consider most significant.

OBJECTIVE 3: Students shall analyze various careers that are appropriate to their aptitudes, interests, and experiences.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
3.1 Students will use the career resource center or library to find career information in as many occupational areas indicated by their interest profiles as possible and will write a job description for at least two occupational titles.	Provide up-to-date information about high-tech career fields and specific occupations in the files of the career resource center. Counselors may wish to include selected sections of Chapters I, and II of this guide; other sources include the Dictionary of Occupational Titles, and COIN or other computer-assisted guidance information.
3.2 Students shall demonstrate awareness of the range of job opportunities in high-technology and the demands and requirements associated with these opportunities.	Teach an instruction unit on occupational clusters related to high-technology careers. Arrange for pairs of students to interview one or more workers in high-tech firms. Provide an interview guide sheet to aid students and perhaps a cassette recorder, so that taped interviews can be stored in the career resource library for future use. Interviews may include questions about job skills, job preparation, personal interests/lifestyle (as related to the relative benefits and demands of the job), the most and least enjoyable aspects of the job.
3.3 Students shall demonstrate awareness of technical applications of math and science studies.	Arrange for students to visit local contemporary science and technology museums. Provide for follow-up experiences in which students enumerate and describe recent applications of scientific research. Arrange with the science teacher to invite a team including a scientist, engineer and technician to visit the class and talk about the research they are currently doing (or past research, if present work is classified). Encourage them to speak about how they solve problems and how they work together.

	Arrange for students to tour a local high-tech facility. Where manufacturing is taking place, arrange for engineering managers to explain to students some of the problems involved in developing a manufacturing process--from the laboratory to the assembly line. Assign students to watch selected science television programs about new and emerging technological applications in manufacturing, medicine, defense, and other fields. Arrange for follow-up activities: discussions, writing, library research, etc.
3.4 Students shall match their own interests, scholastic achievements, and values to appropriate high-tech career information.	Provide students with copies of the list of skills and knowledge required of technicians given in Chapter II of this guide. Ask them to match these lists with their past, current and prospective senior high school credits and, where relevant, with planned postsecondary training. Provide students with the personal accounts of technicians included in Chapter II. Ask them to choose which job of the ones described they find most appealing, which one fits their interests and work values the best.

OBJECTIVE 4: Students shall identify appropriate career opportunities.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
4.1 Students shall discuss employment opportunities with high-tech employers.	Hold a high-tech job fair, ensuring that students interested in jobs at every level from scientist to operator are invited to participate and that industry representatives are prepared to address the questions of vocational/technical students as well as academic students.

4.2 Students shall demonstrate awareness of high-tech job opportunities in their geographical area.	Survey the high-tech employers in your area to find out the number of new employees they hired last year in various categories and their estimates for the coming year. Share survey results with students. Ask them to identify the demand in their chosen category of work. Invite a representative of the local state employment office to speak on job trends and employment in the region. Ask for their perspective on high-tech industry employment. Invite personnel managers from one or more local nonprofit research laboratories to discuss the high-tech job opportunities in those institutions.

OBJECTIVE 5: Students shall select the most relevant educational and/or vocational training program.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
5.1 Students shall identify the different educational alternatives available.	Have students use the career resource library to find three education programs that meet the requirements of their selected occupation. Provide a worksheet with which students can compare commuting distance, cost of tuition and residence, if applicable, number of course offerings, student-teacher ratio, etc. Arrange for students to visit votech centers and community colleges.
5.2 Students shall investigate specific aspects of the postsecondary program in which they are considering enrollment.	Arrange for students who are narrowing their educational choices to telephone department faculty in the technical programs of their choice to ask questions about the program. Relevant questions may include: • Ratio of staff/students. • Laboratory versus classroom hours. • Co-op opportunities included in program.

- Placement record of recent years, including names of employers of recent graduates.
- New or discontinued course offerings or program changes not described in school literature.

OBJECTIVE 6: Students shall formulate and appropriately modify a personal career plan.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
6.1 Students shall develop a career plan for a specific category of work in high technology.	Provide students with career planning forms on which they can record: • Career goals. • Summary of interests/aptitudes/work values matched to their goal. • Summary of occupational outlook previously researched. • Summary of primary skills/knowledge required for job. • Listing of secondary school courses/job experiences relevant to career goal. • Listing of relevant postsecondary school programs by first, second and third choice.
6.2 Students shall develop a hypothetical long-term career path in the field of their choice, based on an initial career plan.	Using previous research and interviews with employers and workers in high-technology fields, students work together to develop a long-term high-tech career path, including long-term potential career changes that occur through re-education, short courses, economic down-turns, etc. This path could take the appearance of a tree with many branches indicating possible options at various junctures--5 years from graduation, 10 years, 20 years, etc. The primary purpose of this exercise is to help students realize that some choices narrow further choices considerably, while others increase the number of options available. Secondly, students can become aware of how external circumstances might affect their careers.

6.3 Students shall have the opportunity to study their chosen occupation through first-hand experience.	Arrange for students who have completed a firm career plan to "shadow" a worker in the selected occupation for one day. Have students share such experiences with each other in a group discussion, through photographic documentation posted on a career bulletin board, or by a written summary of the experience. Where appropriate, arrange for students who have completed a firm career plan to do short-term, part-time or summer internships in a high-technology industry. Although they will probably work as errand persons, laborers, or assemblers, they should still have opportunities to learn about their chosen field.

OBJECTIVE 7: Students shall demonstrate useful employment seeking and employment keeping skills.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
7.1 Students shall practice filling out the appropriate forms and applications required for employment.	Obtain application forms from high-technology firms in the area. Allow students to practice filling out these forms and have other students or teachers evaluate their forms.
7.2 Students shall demonstrate effective job interview skills.	Invite one or more personnel counselors to speak about the purpose of job interviews and the do's and don'ts of good interviews. Allow students to role-play interviews and discuss the experience. Provide students with an interview form with which to solicit information from parents, neighbors, etc., about what they were asked during their last job interview.

7.3 Students shall demonstrate awareness of the qualities that employers look for in applicants and workers.	Ask high-tech employers to speak about the qualities they look for when they interview technicians and the qualities that they consider most important for maintaining employment. Provide students with hypothetical supervisory problems in which the interests/needs/feelings of an employee conflict with those of the supervisor. Arrange for students to role-play solutions to these problems. Generate a discussion among observers of the role-play concerning possible outcomes of the drama, who acted appropriately, etc. Ask students to recall and recount a recent experience in which they encountered evidence of a possible breakdown in work values (job theft, a rude store clerk, a shoddy or faulty product, an inadequate repair job, etc.). Ask them to discuss such instances in terms of their short-term and long-term consequences for the customer, the company and the society.

BROADER IMPLICATIONS OF HIGH TECHNOLOGY

High technology is affecting the content of career guidance activities in an immediate way through the emergence of new occupations and the attention of the workforce. But high technology also has broad, long-term implications for counselors. In a paper presented to the International Graduate School in St. Louis, David Ross compiled a list of future trends that are expected to have an impact on the counseling profession.[33] Some of these trends have been discussed in earlier chapters, and most are paraphrased.

1. The impact of electronic communication and computing will increase access to information and permit instant communication.
2. The composition of American society and the American workforce will change. The median age will continue to rise into the 21st century, and the influence of the most recent wave of immigrants--Hispanics and Asians--will be felt more strongly. More women will enter the workplace, and their role will continue to change.
3. Job skills will change frequently, necessitating retraining and midlife career changes for increasing numbers of people.
4. Economic growth will continue to shift from manufacturing to information and service industries.
5. Smaller organizations, with their ability to be readily responsive to market and other societal changes, may proliferate.
6. Work values will probably continue to shift with more workers wanting flexible scheduling and opportunities to work part-time in order to fit work around family life or lifestyle. Home-based work via computer terminals will contribute to this trend.
7. Education planning may become highly individualized because of computer support.
8. The nations of the world will grow in interdependence.

Future trends such as the ones listed previously can be expected to significantly influence the field of career guidance. At least four changes can be identified in current career guidance literature:

- Strengthening of decision-making skills needed to make career choices--throughout a lifetime of changes.
- Expanding the concept of "career."

[33] Ross describes his list as a condensation of trends cited in works by the following people: Pierre de Chardin, Norman Feingold, Paul Pedersen, Louis Rubin, Alvin Toffler, George Vaillant, Garry Walz, Libby Benjamin, Gilbert Warren, John Whitely and Bruce Fretz.

- Strengthening of abilities to accommodate more information and greater choice in all areas.
- Combining broad-based education with specialty skills/knowledge.

DECISION-MAKING SKILLS TO LAST A LIFETIME

The decision-making skills that students use to arrive at their initial career choices are likely to be revived throughout their lifetimes. Present and future generations of students must become comfortable not only with their initial career choices but also with the process of choice itself. All the steps involved in career choice--career exploration, skills assessment, values clarification and decision-making should become familiar to students who may revive these steps many times in the course of their working lives.

EXPANSION OF THE CONCEPT OF "CAREER"

The narrow term "career planning" has in recent years been expanded in some of the literature to "career/life/work" planning. This expansion of terms reveals the flexibility as well as the ambiguity with which many guidance professionals are facing the need to counsel students for an era of change. As one writer asks, "Do we counsel individuals for 'career' choice or 'occupational' choice?"[34] There are several possible answers to this question. Perhaps avocations will become more important as fewer people work at one job or in one field throughout their lives. Some writers have suggested that the relationship between work and leisure must change, with leisure becoming more highly valued rather than being seen as nonproductive.[35] We might also expect fewer people to feel that their identities are defined exclusively by the work that they do. Career may come to mean "life's work" in a broad, inclusive sense. Part of the work of the counselor will be to present students with these optional ways of defining "career."

ACCOMMODATION OF MORE INFORMATION, GREATER CHOICE

Changing life and work patterns have already brought the problem of "information overload" to persons both on and off the job. Workers in high-tech fields may be especially plagued by overload as they try to keep up in their fields.[36] However, the problem of making reasoned choices in a

[34] Cianni-Surridge.
[35] Ibid.
[36] Ibid.

society where information is proliferating is not restricted to high-tech workers; it is already faced by many of us. Therefore, decision-making and problem-solving skills mentioned earlier will be important not only for career choices but also for the selectivity that will be needed in every aspect of life. For more than a decade, many children have heard the parental refrain, "When I was young, we didn't have a choice!" However, children today have a choice about what kind of work to do, whom to marry, where to live, what to read, what to watch, where to vacation, what to eat, what kind of bed to sleep in, and a thousand other aspects of life. In the face of overwhelming information and a myriad of options, many retreat into decision-by-default, while others search for a rigid system of belief that will dictate their choices. Others make decisions by process of elimination. The counselor's role in teaching people how to make reasoned choices will become ever more important in the years to come.

BROAD-BASED EDUCATION FOLLOWED BY SPECIALTY TRAINING

A broad-based education followed by training in specialty skills for the technical workforce is a departure from the traditional voc-ed emphasis on current employable skills to the exclusion of broad-based knowledge. The counseling role of the school guidance professional will be very much affected by this trend in two ways. First, the relationship between "the basics" and a subsequent career must be conveyed to students. Second, students will need guidance and career information in order to chart highly specialized and, in some cases, individualized programs of study. Labor market information will be an important part of career planning, especially for the selection of specialty skills or interdisciplinary skills. Already we see students combining educational options in unique ways. Some examples include the young graduate with a business major who takes a year of laser/electro-optics training before entering the laser field in a managerial position; the graduating solar energy technician who decides to spend an extra year in the building trades program in order to work in the solar home-building field, and the many students who combine computer programming courses or majors with fields such as technical writing, advertising art, communications, or chemistry.

COMPUTER-ASSISTED GUIDANCE

The achievement of career decision-making objectives in the U.S. is being affected by the availability of computer-assisted guidance. Computer-assisted guidance (CAG) is an umbrella term that may be applied to a variety of computer-assisted systems that provide occupational information and/or career guidance.[37] The core of most CAG systems is a data base of information regarding occupations, employment outlook projections, financial aid opportunities, apprenticeships, and so forth. Students gain access to the data in most CAG systems by specifying preferred job or career characteristics such as salary level, work values, location requirements, and social factors. The computer responds by displaying a list of occupations that fit the given characteristics. Some computer-based systems are highly interactive. They carry the student through an exploratory process of narrowing choices and provide feedback concerning the result of each decision. For example, students using CHOICES (Computerized Heuristic Occupational Information and Career Exploration System) can ask the computer questions:

> "Why wasn't I given 'computer programmer' as an occupation?" a student may ask. And the computer would answer: "In question #14 you responded that you didn't like math. Math skills are essential to a computer programmer. In question #21 you said you wanted to work an eight-hour day. Computer programmers often work overtime..."[38]

Some computer-assisted guidance systems go beyond the information storage and retrieval functions and even beyond the interactive capabilities of a system such as CHOICES. They attempt to present a systematic approach to the career decision-making process, a process that can be used in subsequent career transitions.[39] These systems are also capable of storing and retrieving information about users such as grades, interests, values, skills, and test scores.

Computer-assisted guidance has been encouraged by federal grants to states as a result of legislation designed to address economic dislocations and labor market imbalances. Through the National Occupational Information Coordinating Committee (NOICC) and the state counterparts, State Occupational Information Coordinating Committees (SOICCs), computer-assisted guidance

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[37] Lawrence Shatkin. "The Electronic Counselor," Electronic Learning. Sept. 1983.

[38] Shatkin, Lawrence.

[39] Jacobson and Grabowski.

systems, as well as other occupational information delivery systems (microfiche, printed matter, films), have been funded. The statewide coordination of computer-assisted guidance systems has made possible the dissemination of up-to-date, locally relevant career information.

Computer-based systems can be divided into three categories: batch-process systems, on-line career information systems, and on-line career guidance systems.[40] Batch-process refers to systems in which users fill out paper forms indicating career preferences, interests and personal characteristics. These forms are sent in a "batch" to a selected computer site where they are processed; the user receives a printout of relevant occupational information up to two or three weeks later. On-line career information systems allow users to tap large data files directly using remote terminals. They also allow for self-assessment and dialogue with the computer to control the retrieval of information. CHOICES is an example of an on-line career information system. On-line career guidance systems have highly sophisticated components that teach values clarification or career decision-making. Some computer-based systems are designed to run on microcomputers; others are used with minicomputers and dial-up access to a mainframe. The computer hardware, as well as the software of the system may be purchased or leased; the software must be updated periodically. A complete comparison of computer-assisted guidance systems is beyond the scope of this guide. However, the following discussion of the effectiveness of computer-assisted guidance systems provides some basis for comparison among systems.

EFFECTIVENESS OF COMPUTER-ASSISTED GUIDANCE

Computer-assisted guidance systems have certain outstanding features that render them ideal for career exploration. The computer capacity for storage and retrieval of large amounts of occupational data far exceeds what can be collected, organized, maintained, and disseminated by a single counselor. CAG data bases can be updated continually as labor market information changes. Recently, the occupational data generated by government agencies is being supplemented in many systems by qualitative data gathered by occupational reviewers. In a functional system that is well-maintained, students have the advantage of the most reliable, current information available. In addition, some systems include placement components. For example, the CHOICES program in Florida is connected to the job bank of the Florida State Employment Service. Students can receive a printout of current openings that fit their specified characteristics. At one large Miami high

[40] Ibid.

school, a full-time state employment service representative is on hand to place students in jobs they have discovered through computer interaction.[41] The speed at which computers can produce requested information is another comparative advantage over print media and films. Students can work through all aspects of career exploration--from assessment to placement--more quickly than they can using conventional methods.

A second important feature of CAG systems is their personal quality. The information presented to students is based upon their unique combination of responses to assessment questions and is, therefore, relevant to their particular interests and circumstances. CAG systems are interactive as film and print media cannot be. Furthermore, students can use the computer in privacy. Students can ask computers "dumb" questions and reveal ambitions that they might not want to reveal to another person.[42] Assessment can take place without the subtle biases or opinions that are sometimes interjected by people administering assessments.

Finally, CAG systems can give students ample practice and instruction in career decision-making. The computer can require students to follow a logical sequence of self-assessment, career exploration, values clarification, and career decision-making.

Problems can arise with the use of CAG systems, and even the best systems have limitations. First, computer-assisted guidance programs must be chosen to fit the needs of the students they are serving. For example, a system that contains a great deal of information about professional careers but little information about trades and technical occupations will serve the needs of vocational students very poorly. Second, the system is only as good as its information is accurate and up-to-date; CAG system information should compare favorably with published data in this regard. Third, computer hardware is subject to occasional problems; students confronted with computer equipment failure may experience frustration. Finally, CAG systems are not intended to be total career guidance programs. Ideally, the computer will free counselors from the rote aspects of dispensing career information, permitting them to concentrate on primary counseling activities with groups and individuals.

ETHICAL ISSUES IN COMPUTER-ASSISTED GUIDANCE

The use of computers in counseling may present ethical problems. Specific ethical issues have been raised in the counseling community concerning the confidentiality of client data, the use of computer-assisted testing and

[41] Shatkin.
[42] Ibid.

assessment, and the need for counselor intervention.[43] The problem of confidentiality applies primarily to computer-assisted guidance other than career information systems. The concern is that sensitive student or client information will be incorrectly entered; used for other than therapeutic purposes; viewed by unauthorized persons; maintained for longer than necessary; or used for unauthorized research purposes.[44] Computer-assisted testing and assessment are subject to at least two potential problems: (1) computer error in scoring, and (2) misleading or confusing generalized interpretations of test results as conveyed by means of the computer.[45]

The need for counselor intervention has been broadly addressed by some people resistant to computer-assisted guidance systems because of the image of the computer as dehumanizing. Other writers who accept computer applications in guidance have raised specific questions about intervention. Sampson and Pyle assert:

> "...some individuals who are experiencing substantial emotional problems initiate their contact with a service agency by asking for specific information such as communication skills, motivation, or career choice."[46]

Such individuals may interpret being directed to the nearest computer terminal as a rejection or a confirmation of their inability to establish human contact. Others may be in a crisis so severe that they are unable to use the computer effectively or interpret correctly the information obtained.

Anxieties can arise in computer use even with students who are not experiencing an emotional crisis. Some people have anxiety about using a computer, because they think that it requires a lot of math expertise; still others are afraid that they will damage the computer or erase the program.[47] Proper orientation to the CAG system can prevent misunderstandings and anxieties associated with computer use. Studies have indicated that female students are less likely to use computers than their male peers and thus they may require extra encouragement from the counselor. Proper follow-up of student computer use is equally important for identifying problems in computer use as well as other counseling needs of the student.[48]

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[43] James Sampson and Richard K. Pyle. "Ethical Issues Involved With the Use of Computer-Assisted Counseling, Testing, and Guidance Systems," The Personnel and Guidance Journal. Jan. 1983.

[44] Ibid.

[45] Ibid.

[46] Ibid.

[47] Sampson and Pyle.

[48] Ibid.

The need for counselor intervention has been met in some cases by having students use CAG systems as part of a total career guidance course in which considerable time is given to orientation and follow-up. Other strategies for intervention include informal assistance by counselors provided at the student's request and scheduled appointments by counselors.

COUNSELOR ATTITUDES TOWARD COMPUTER-ASSISTED GUIDANCE

In the successful implementation of computer-assisted guidance systems, the attitude of the counselor is critically important. Counselor response to CAG systems is bound to be affected by the individual's feelings about technology in general. Some counselors may perceive themselves as the "last bastion of humanism within the school"[49] and take particular exception to the introduction of a computer in the counseling domain. Others may see the computer as a threat to their job security. Garry Walz suggests that technology--including counseling technology--forces users to delineate clearly their values and goals, and that the conflicts engendered by new technologies make it easier to see the differences in values among people.[50] Presumably counselors will be able to see this process of values clarification in a positive way. Walz observes five levels of technology use (including computer guidance systems) among counselors and educators. These are listed below[51] as a guide for those who wish to examine their own attitudes toward counseling technology:

- The "we don't need it" contingent often sees money as the best reason not to introduce technology or even to examine its uses.
- The "look at what we've got" group often selects the most visible gadgetry available, sometimes without full consideration of how it fits into the overall program.
- "Go, technology, go" is the motto of some who seek to be identified as progressive. Unfortunately, their enthusiasm often wanes quickly because technology is not tied to specific program objectives.
- "We've taken care of everything" is often the smug assertion of those who take the systems approach. But the variables of personalities, places, histories, etc., are not always predictable, nor perhaps should they be.

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[49] Anthony Gamboa, William Kelly, and Thomas Koltveit. "The Humanistic Counselor in a Technocratic Society," The School Counselor. Jan. 1972.

[50] Walz, Garry. "Technology in Guidance: A Conceptual Overview," Personnel Guidance Journal, Vol. 49, Number 3, Nov. 1970.

[51] Ibid.

- The "integrative approach" recommended by Walz takes into account various procedures and practices with a strong concern for the process of participatory decision-making. The emphasis is at once on the outcomes of the decision to adopt a new technology and on the way such a decision is made. This approach "integrates hardware, people, and social setting."[52]

Computer-assisted guidance, in the most optimistic view, promises to free the counselor from rote tasks and permit concentration upon the most humanistic of counseling activities--personal interaction. Even the most sophisticated computers are unable to appropriate the vital function of person-to-person communications. In their scrutiny of computer-assisted guidance, counselors have the choice of redefining their roles to include more creative and satisfying work with students.

[52]Gilbert C. Wrenn. Personnel and Guidance Journal. 19, No. 3, Nov. 1970.

CHAPTER V. HIGH-TECHNOLOGY RESOURCES

IN THIS CHAPTER ...

- A discussion of the counselor's need for up-to-date labor market information.
- Publications and information from government agencies and independent publishers.
- Plans for building school-industry relationships.

Counseling professionals are faced increasingly with the need for current labor market information. High technology is changing the entire occupational structure as well as creating new skill requirements at a rate much faster than in years past. Vocational counselors who provide career information to students on a daily basis must be aware of current occupational changes, yet must have enough quality information to avoid being "bandwagon-jumpers." In many school systems, counselors rely on the knowledge gained during their professional schooling and occasional in-service training. But counselors who are only superficially aware of labor market changes and new occupations are at a great disadvantage when they advise students. For example, in the 1970s, many technology forecasters and "popular science" writers believed that solar energy technology was about to undergo widespread growth and development and that there would soon be a high demand for solar energy technicians. Counselors observing the solar technology trend on a superficial level may have counseled students that solar technology was the field of the future. But the expectations of the more enthusiastic forecasters and of some of the students who decided to enter the field were never met. A more cautious approach was taken by those who read more deeply about the current state of solar technology and who obtained current labor market information about the number of job openings for solar technicians.

Counselors suffer greatly from lack of current career information in their role of motivating students. As mentioned previously, students are often unaware of the relationship between their current coursework and the skills and knowledge required in a high-tech career. The counselor points out that relationship by bringing "real-world" information to students and by arranging for students to be exposed first-hand to what is going on in industry. Therefore counselors need continuously to update their employment information and to maintain contacts with high-tech industry. Most counselors are seeking an awareness of new careers that is factually based yet deeper than can be provided by statistics alone.

SOURCES OF LABOR MARKET AND HIGH-TECH CAREER INFORMATION

Various magazines written for counseling professionals address major occupational trends; some include anecdotes and occupational profiles of individuals in the field. Besides these sources, counselors who want to understand more about the nature of high technology will want to pay attention to some of the magazines that explain the latest research and applications in various high-tech fields. A list of these publications is include in Appendix D of this guide.

The major source of statistical data on employment, unemployment and occupational trends is the Bureau of Labor Statistics of the U.S. Department of Labor. BLS uses the Current Population Survey, conducted by the Bureau of the Census and takes a scientifically selected sample of 65,000 households designed to represent the civilian noninstitutional population. Special surveys are conducted periodically and monthly statistics on the U.S. employment status are collected. A booklet of questions and answers, Workers, Jobs, and Statistics, has been published by the BLS to explain how and where they get their information. Another booklet, Current BLS Publications, lists available publications of the BLS; these publications cover a wide range of topics from nationwide unemployment statistics to readings on productivity, technology and labor, and female and minority employment perspectives. The Occupational Outlook Handbook is another BLS publication used by many counselors. Besides the career descriptions in the handbook professional societies and trade groups are listed in the guide. One counselor reported that she had greatly expanded the student career library by mailing a simple form letter to the societies listed at the end of each career article in the Occupational Outlook Handbook. The response was overwhelming. A sample form letter to be used for such a mailing is listed at the back of this guide in Appendix E.

Counselors may find the Monthly Labor Review published by the BLS an especially helpful periodical; its articles about employment trends usually contain summaries, analyses and interpretations accompanied by graphs and charts depicting the background data. Recent issues have included articles on work and income patterns of two-earner families, unemployment in durable-goods manufacturing, and reports on the wages of appliance technicians. The Monthly Labor Review and some other publications of the BLS are listed in Appendix D of this guide, along with a listing of the regional offices of the BLS. Some regional offices mail regular reports (free of charge) to interested persons; these reports list new publications as they become available for order. Many reports are free and some others are available at a relatively low cost.

Counselors may wish to concentrate their information gathering within the state or regional area. A list of the state employment agencies is provided in Appendix D. Local branches of the state employment securities agency are often directly helpful in placement of students as well as providing general employment information to counselors. Many counselors have one or two contacts in the local agency with whom they confer on a regular basis.

In the face of so much information, some counselors may feel bombarded, and justifiably so. If all the sources listed here were to cross one's desk, the stack might well block one's view of the students on the other side of it! Counselors would do well to sample some of these sources and choose the most reliable and relevant to receive on a regular basis. The point is that "real-world" information about high-tech careers should be coming into the school on a frequent and regular basis.

In the case of career information that is to be dispensed to students, it is essential to have a filing system for quick reference and organization. Brochures that are shelved are often misplaced. The best career library we visited made use of a vertical filing system using the DOT occupational numbers. A handy rolodex file was alphabetically arranged by occupational titles, which referred the student to the appropriate DOT number in the file. In that way, career information could be located through several different job titles; robotics technicians might also be listed in the rolodex file as automated manufacturing technicians, or electromechanical technicians, but all of these titles would refer the student to the same numbered file of pamphlets or magazine articles as well as to appropriate audiovisual materials. These numbers also correspond to those used in the Occupational Outlook Handbook.

BUILDING SCHOOL-INDUSTRY RELATIONSHIPS

In addition to written sources, most counselors will want to establish contacts with local and regional employers. By going to high-tech industries, counselors can ascertain directly current employment requirements and opportunities available to their students.

Some vocational education departments have established relationships with business and industry through program advisory committees, industry co-ops, or placement programs. Counselors will want to investigate the potential for expanding already established networks to accommodate broader career information activities. (However, no single employer should be asked to assume the entire responsibility of participating in career education for the high-technology area.) Initiating contact with a community firm requires forethought and background information. Counselors can often find

out which companies to approach by reading the Chamber of Commerce newsletters and the business pages of local papers, and by contacting local employment agencies. Knowing whom to contact within a given company is important in saving the counselor's time and in avoiding unproductive avenues of search. Large firms often have a community relations department that works with schools in needed capacities. Engineering managers and personnel managers may be helpful, also.

Some schools or local education agencies may wish to sponsor their own high-tech career information search. A sample letter and form for this purpose are provided in Appendix E of this guide.

APPENDIX A
PRINCIPLES OF TECHNOLOGY

The Principles of Technology course covers 14 principles, contains approximately 150 laboratory exercises and demonstrations, and has about 500 minutes of video presentations. One possible teaching pattern for this course is shown in the accompanying figure. This implementation strategy is based on 50 minutes of instruction each day of the week for two years, so that fourteen concepts can be covered thoroughly.

PRINCIPLES OF TECHNOLOGY

FOUR-WEEK PRESENTATION STRATEGY FOR ONE TECHNICAL CONCEPT

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
WEEK 1	5-MINUTE VIDEO – CONCEPT 7-MINUTE VIDEO – MECHANICAL APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON MECHANICAL APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB – MECHANICAL APPLICATION OF CONCEPT	HANDS-ON LAB – MECHANICAL APPLICATION OF CONCEPT
WEEK 2	7-MINUTE VIDEO – FLUID APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON FLUID APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB – FLUID APPLICATION OF CONCEPT	HANDS-ON LAB – FLUID APPLICATION OF CONCEPT
WEEK 3	7-MINUTE VIDEO – ELECTRIC APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON ELECTRICAL APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB – ELECTRICAL APPLICATION OF CONCEPT	HANDS-ON LAB – ELECTRICAL APPLICATION OF CONCEPT
WEEK 4	7-MINUTE VIDEO – THERMAL APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON THERMAL APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB – THERMAL APPLICATION OF CONCEPT	HANDS-ON LAB – THERMAL APPLICATION OF CONCEPT VIDEO REVIEW OF CONCEPT

During the first year, approximately four or five weeks of instruction would be provided for each topic as follows:

Force	Resistance
Work	Energy
Rate	Power
	Force Transformers

Any time remaining can be devoted to fostering students' familiarity with high-tech careers and current employable skills.

In the second year, approximately four weeks of instruction are devoted to each of these topics:

Momentum
Waves
Energy Convertors
Transducers
Radiation
Optical Systems
Time Constants

Each unit of instruction can be delivered according to the schedule shown on the previous page. Each week of the four-week period is spent usually studying one system--mechanical, fluid, electrical or thermal. Discussions, demonstrations and video tapes are provided on the first two days of each week. On the third day, students encounter individualized "problem-solving math labs" where they would practice the needed math skills for applications of the technical concepts and principles. Using specially-prepared print materials and procedures, these labs strengthen skills in the arithmetic areas of fractions, decimals, percentages, and in simple algebra, basic trigonometry, dimensional analysis, SI units (including the metric system), graphing, vectors, logarithms and exponents. The last two days of each week are spent in the laboratory where the student builds, observes, operates, tests, and measures the physical phenomena under study while using practical, easily-obtainable equipment such as hydraulic jacks, pumps, motors, brakes and fiber optics. Optional exercises involving robots, lasers, and computers are available for schools with these resources.

Laboratory exercises and demonstrations are a key aspect of instruction. Students spend 50 percent of their time in the applications labs. It is by this hands-on learning that students gain a fundamental understanding of the concepts, principles and systems they are studying. Through the lab experiences, they develop comprehension of the underlying similarities and differences among systems and, through applications in the lab, they develop practical problem-solving skills.

The print and video presentations serve as the skeleton supporting the laboratory experiences. They provide students with a basis for understanding the significance of the laboratory experiences, for conducting the laboratory procedures in a safe and efficient manner, and for making generalizations across systems. Print and video materials also provide a foundation for teachers who are not familiar with the course's content. A comprehensive Teacher's Guide ensures that such teachers can learn from the

materials as they teach them. The print, video and Teacher's Guide help teachers better understand the content, develop ways to explain ideas clearly and concisely to students, and provide teachers with a basis for the development of interesting and effective hands-on learning experiences.

Each unit of instruction incorporates a minimum of six video presentations. On the first day of each cycle, a short video presentation introduces the new topic of study, relates the topic to the previous topics, and presents forthcoming learning activities. Video presentations introduce each subunit within a unit. Each video program emphasizes a particular system and the relationship of that system to the specific topic of study (for example, force or rate or energy). Typically, the video shows large systems and equipment that students otherwise would not be able to study--systems such as electrical power plants, rocket-propelled space vehicles, and automated manufacturing cells. Each unit is concluded with a video review of the topic under study. This review reinforces the interrelationships among concepts, principles and systems. Videotapes are also used occasionally to introduce career opportunities, to provide role models and to give students insight into the nature of technical careers.

APPENDIX B.
WORKING MODEL FOR PRETECHNICAL STUDIES

High school graduation requirements may vary from state to state and within local communities. Pretechnical studies programs, where proposed, would be implemented with respect to existing requirements. A hypothetical model of existing credit requirements is provided below, and a proposed pretechnical studies curriculum is shown as it would fit into the existing program. This hypothetical model is somewhat more demanding than existing requirements in most states; however, 15 of the 50 states are now considering revisions to increase graduation requirements (Vocational Training News, Vol. 15, No. 10, Mar. 8, 1984).

HYPOTHETICAL CREDIT REQUIREMENTS	
English	4 credits
Mathematics	3 credits
Science	3 credits
Social Studies	3 credits
Physical Science	1 credit
Electives	6 credits
TOTAL CREDITS REQUIRED FOR GRADUATION =	20

If the technical core curriculum were adapted to fit such requirements, the courses could be combined as shown in the following plan. The newly introduced technical core courses are delineated by asterisks.

9th Grade

ENGLISH (1 credit)
SOCIAL STUDIES (1 credit)
PHYSICAL EDUCATION (1 credit)
MATH (1 credit)
ELECTIVE (1 credit)

10th Grade

ENGLISH (1 credit)
SOCIAL STUDIES (1 credit)
LIFE SCIENCE (1 credit)
APPLIED MATH/DEVICES AND MEASUREMENTS* (1 math credit)
MATH (1 credit)

11th Grade

ENGLISH (1 credit)
SOCIAL STUDIES (1 credit)
PRINCIPLES OF TECHNOLOGY* (1 science credit)
CURRENT EMPLOYABLE SKILLS (1 credit)
CURRENT EMPLOYABLE SKILLS (1 credit)

12th Grade

ENGLISH (1 credit)
KEYBOARDING/COMPUTER LITERACY* (1 credit)
PRINCIPLES OF TECHNOLOGY* (1 science credit)
CURRENT EMPLOYABLE SKILLS (1 credit)
CURRENT EMPLOYABLE SKILLS (1 credit)

*Newly introduced technical core courses.

Such a curriculum plan would provide the vo-tech student with an excellent foundation for subsequent specialty training or employment after high school. However, there are problems in this model:

- The vo-tech student is required to take two math courses concurrently in the 10th grade.
- The vo-tech student would have a highly structured course plan, with only one elective.
- The vo-tech student would not have hands-on training or significant laboratory experience until the 11th grade.

Some of the major advantages include the following:

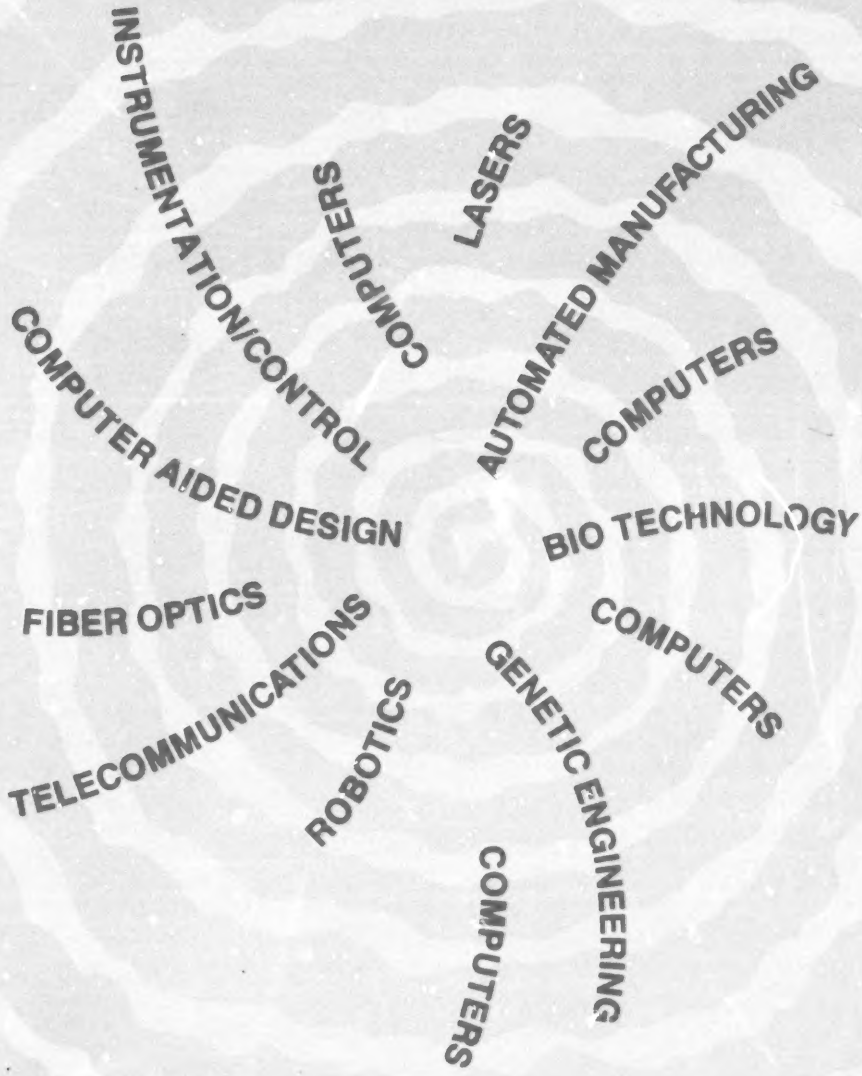
- Broad-based math and technological foundation is excellent.
- Two-fifths of the 11th and 12th grade curriculum involves current, employable skills.
- Principles of Technology allows for extensive laboratory experience.
- Student can choose work or school after graduation.

APPENDIX C. CHARTS AND ILLUSTRATIONS

The following charts and illustrations used in the guide have been reproduced on full pages in this Appendix so that they can be used as masters for overheads or other visuals to support oral presentations.

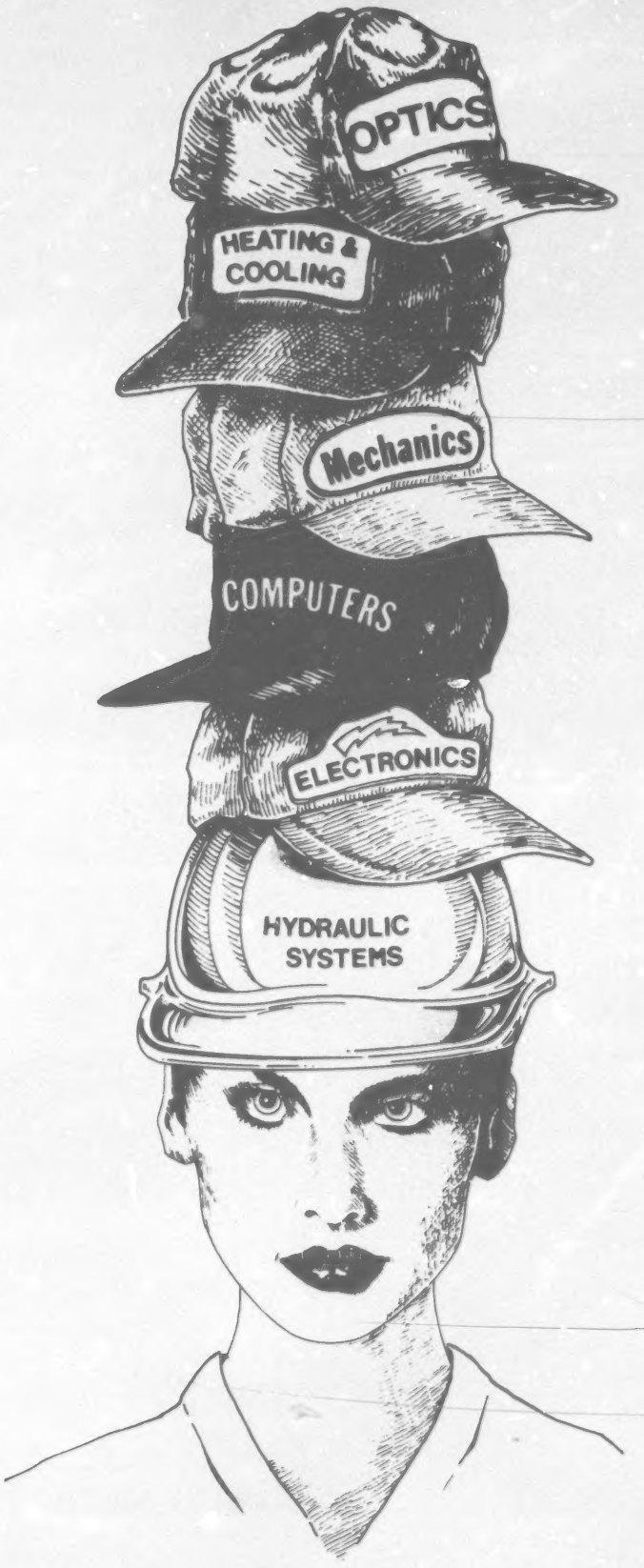
I. The Expanding Pool of Scientific and Technological Information
II. Four Characteristics of High Technology
III. Today's Technicians Wear a Lot of Hats
IV. Impact of High Technology on Occupational Structure
V. High Technology Is Changing the Way We Work
VI. High Technology Sometimes Leads to Worker Displacement
VII. Six Changes on the Employment Scene
VIII. Educational Requirements in a High-Tech Society
IX. Four Careers in High Technology
X. Tasks Performed by Technicians
XI. Different Types of Technicians
XII. A Polarization in Educational Philosophy
XIII. Pretechnical Career Education
IV. Typical High-Tech Programs

THE EXPANDING POOL OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION



FOUR CHARACTERISTICS OF HIGH TECHNOLOGY

- Broad knowledge base
- Rapid change
- Heavy computer use
- Systems-orientation

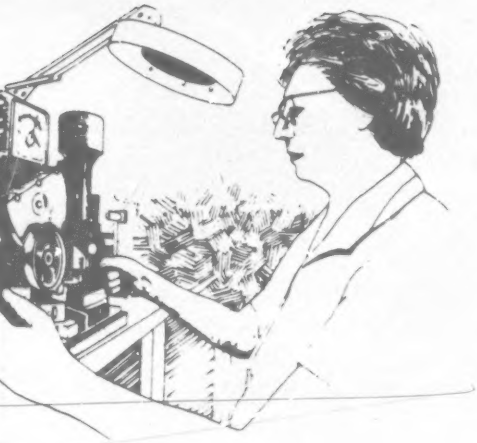


Today's technician wears a lot of

HATS—

THE IMPACT OF HIGH TECHNOLOGY ON THE OCCUPATIONAL STRUCTURE

LESS GROWTH IN JOBS LIKE THESE . . .



MORE GROWTH IN JOBS LIKE THESE . . .

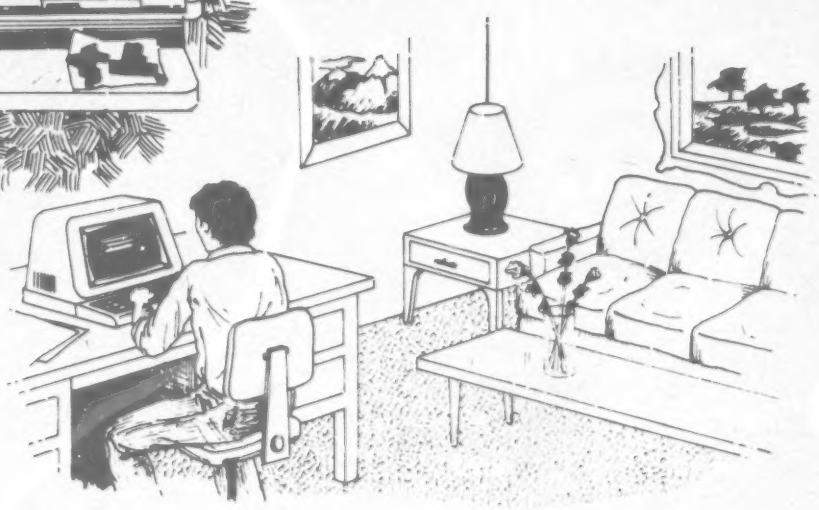
INDUSTRIAL ECONOMY → **INFORMATION ECONOMY**

HIGH TECHNOLOGY IS CHANGING THE WAY WE WORK . . .

- Decentralization of the workplace

FROM THIS . . .

TO THIS . . .



- More people linked to the economy

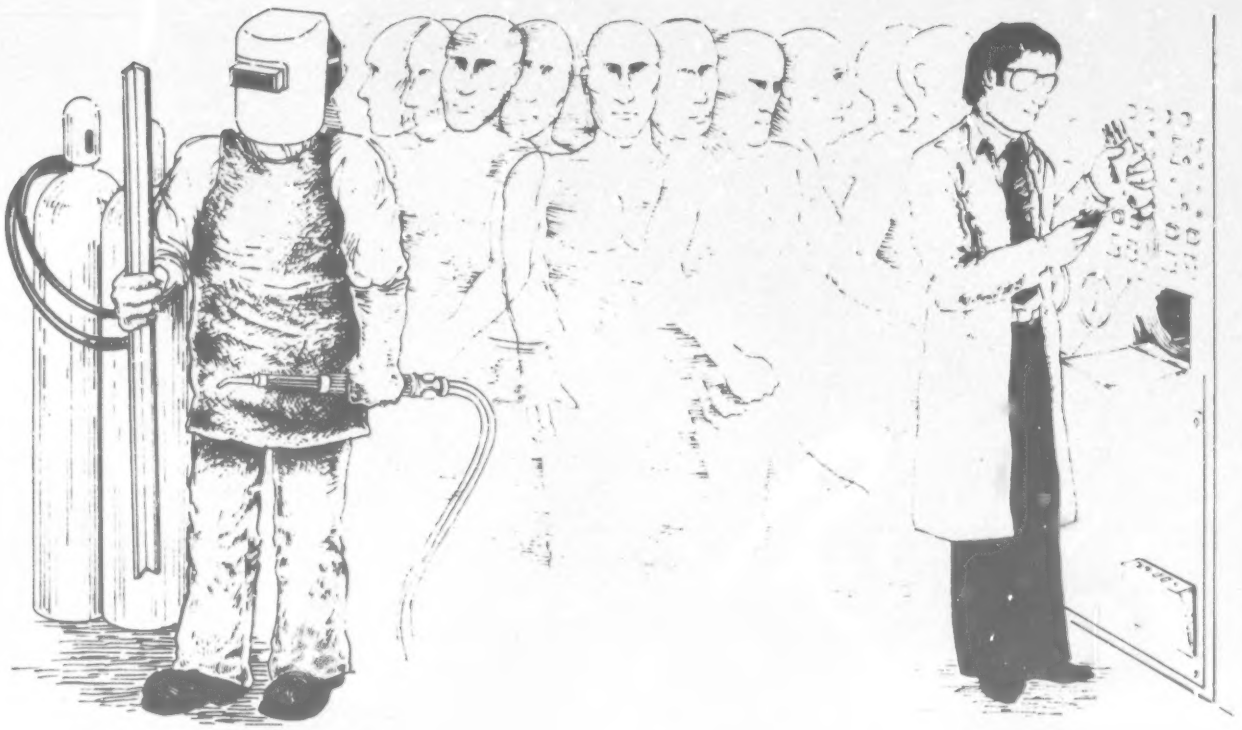
RURAL CITIZENS
HOMEMAKERS
SENIOR CITIZENS
DISABLED PERSONS

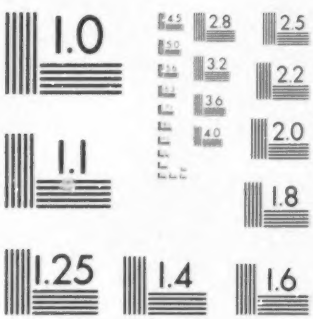
ORD

HIGH TECHNOLOGY SOMETIMES LEADS TO

WORKER DISPLACEMENT

- Some people **LOSE JOBS**.
- Some people **RETRAIN** within the company or in a related field.
- Some people **CHANGE CAREERS** entirely.





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

SIX CHANGES ON THE EMPLOYMENT SCENE

- Moving toward an information and service economy
- Traditional semiskilled factory jobs on the wane
- More low-skilled jobs which involve little or no training and low pay
- Two out of three new workers female and/or minority
- In demand--a well trained technical workforce for high-tech industries
- A growing trend--mid-career changes

EDUCATIONAL REQUIREMENTS IN A HIGH-TECH SOCIETY

BASICS

MORE MATH
MORE SCIENCE
COMPUTER FUNDAMENTALS
READING/WRITING
SOCIAL STUDIES

SKILLS

COMMUNICATION
ANALYTICAL PROBLEM-SOLVING

QUALITY

HIGHER STANDARDS OF EXCELLENCE FOR ALL STUDENTS

FOUR CAREERS IN HIGH TECHNOLOGY

SCIENTIST

DEVISES MATHEMATICAL MODELS TO MAKE THEORETICAL DESCRIPTIONS OF DEVICES AND SYSTEMS

POSES QUESTIONS AND THINKS OF WAYS TO TEST IDEAS AND HYPOTHESES

USUALLY HAS A Ph.D.

ENGINEER

DESIGNS ACTUAL DEVICES AND SYSTEMS - - CHOOSING MATERIALS, PARTS, ETC. THAT ARE COMPATIBLE WITH THEORETICAL DESCRIPTION OF THE SCIENTIST

DESIGNS EXPERIMENTS BASED ON THE SCIENTIST'S NEED FOR TESTING A HYPOTHESIS

HAS A BACHELOR'S OF SCIENCE IN ENGINEERING

TECHNICIAN

BUILDS, TESTS, AND FIXES DEVICES AND SYSTEMS

SETS UP AND MONITORS EXPERIMENTS

USUALLY HAS AN ASSOCIATE DEGREE

OPERATOR

OPERATES DEVICES AND SYSTEMS

DOES ROUTINE MONITORING AND SUPPORT WORK

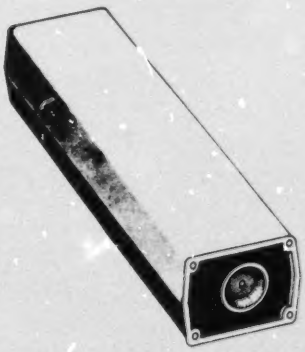
USUALLY HAS A HIGH SCHOOL DEGREE, SOMETIMES A CERTIFICATE OF ADDITIONAL TRAINING

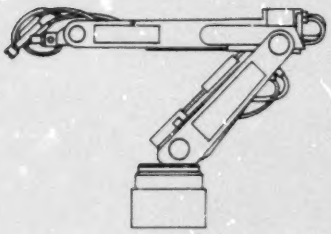
TECHNICIANS PERFORM THE FOLLOWING KINDS OF TASKS:

1. PERFORM TESTS ON MECHANICAL, HYDRAULIC, PNEUMATIC, ELECTRICAL, OR THERMAL COMPONENTS OR SYSTEMS; PREPARE APPROPRIATE TECHNICAL REPORTS COVERING THE TESTS.
2. OBTAIN, SELECT, COMPILE, AND USE TECHNICAL INFORMATION FROM PRECISE MEASURING AND RECORDING INSTRUMENTS.
3. ANALYZE AND INTERPRET INFORMATION OBTAINED FROM PRECISE MEASURING AND RECORDING INSTRUMENTS AND SPECIAL PROCEDURES AND TECHNIQUES.
4. PREPARE OR INTERPRET ENGINEERING DRAWINGS AND SKETCHES; WRITE DETAILED SPECIFICATIONS OR PROCEDURES FOR WORK.
5. DESIGN, HELP DEVELOP, OR MODIFY PRODUCTS, TECHNIQUES, AND APPLICATIONS IN INDUSTRIAL SETTINGS.
6. PLAN, SUPERVISE, OR ASSIST IN THE INSTALLATION AND INSPECTION OF COMPLEX SCIENTIFIC APPARATUS, EQUIPMENT, AND CONTROL SYSTEMS.
7. OPERATE, MAINTAIN, AND REPAIR COMPLEX APPARATUS AND EQUIPMENT WITH EXTENSIVE CONTROL SYSTEMS.
8. ADVISE, PLAN, AND ESTIMATE COSTS AS A FIELD REPRESENTATIVE OF A MANUFACTURER OR DISTRIBUTOR OF TECHNICAL APPARATUS, EQUIPMENT, SERVICES, AND/OR PRODUCTS.
9. APPLY KNOWLEDGE OF SCIENCE AND MATHEMATICS WHILE PROVIDING DIRECT TECHNICAL ASSISTANCE TO PHYSICAL SCIENTISTS OR ENGINEERS ENGAGED IN SCIENTIFIC RESEARCH AND EXPERIMENTATION.

DIFFERENT TYPES OF TECHNICIANS

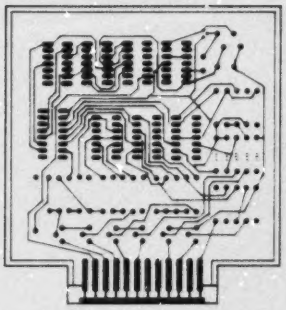
LASER TECHNICIAN



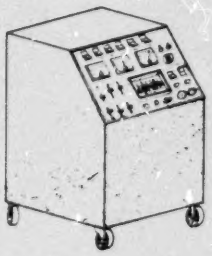


ROBOTICS
TECHNICIAN

INSTRUMENTATION AND
CONTROL TECHNICIAN



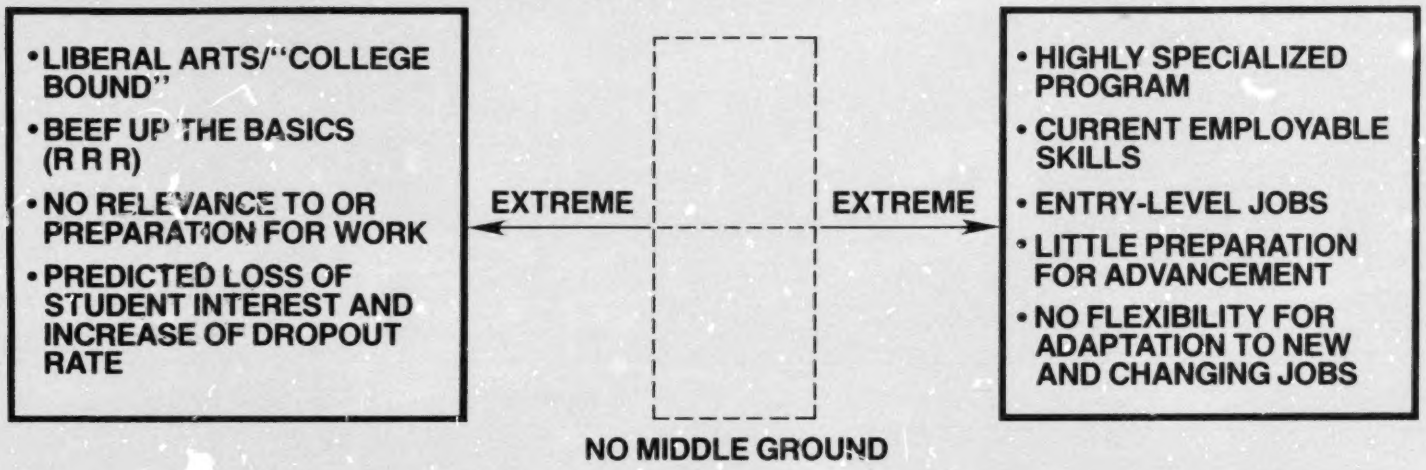
ELECTRONICS
TECHNICIAN



BIOMEDICAL
EQUIPMENT
TECHNICIAN

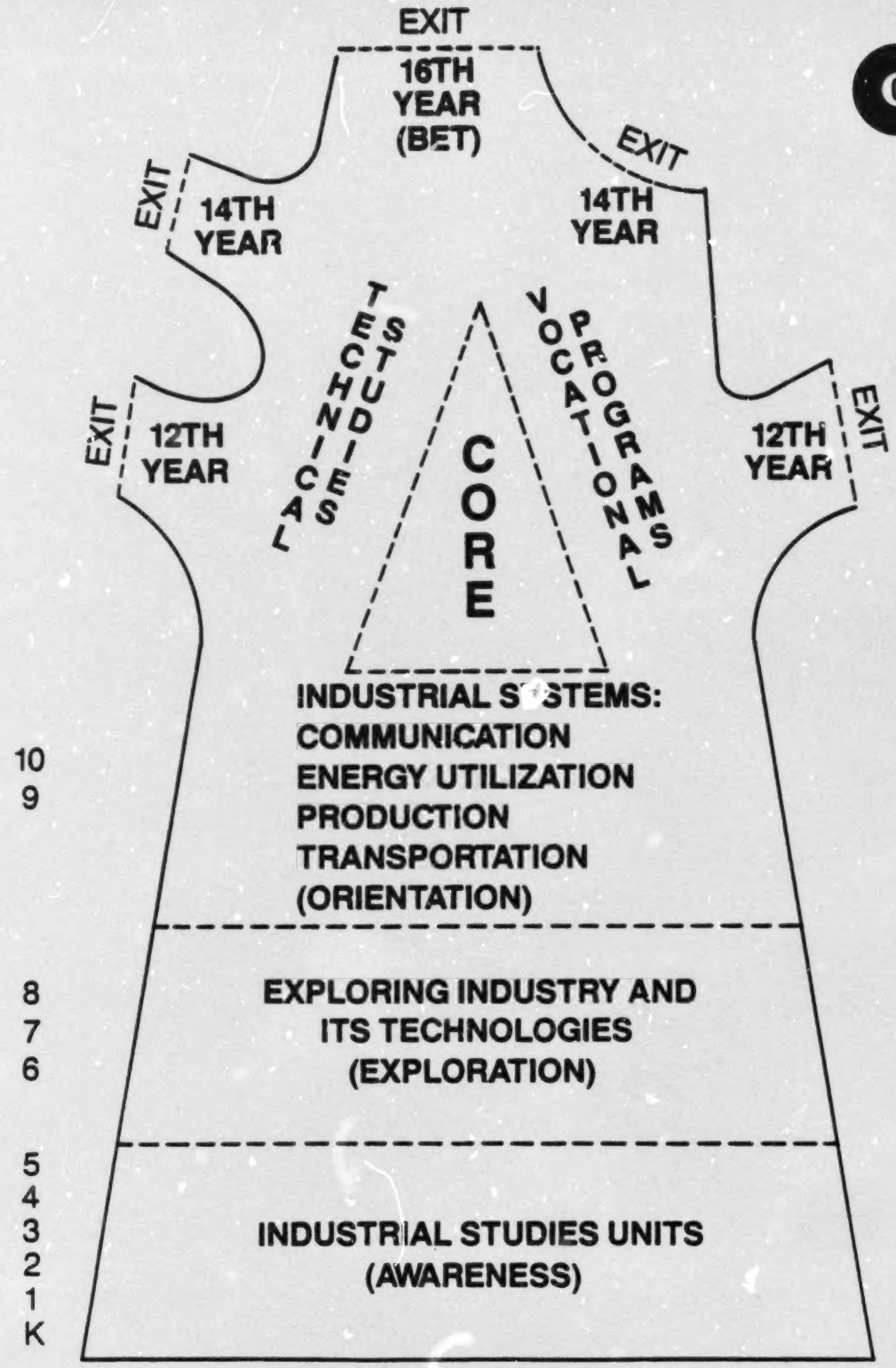
COMPUTER SERVICE
TECHNICIAN

A POLARIZATION IN EDUCATIONAL PHILOSOPHY RESULTING FROM THE "HIGH-TECH CRISIS"

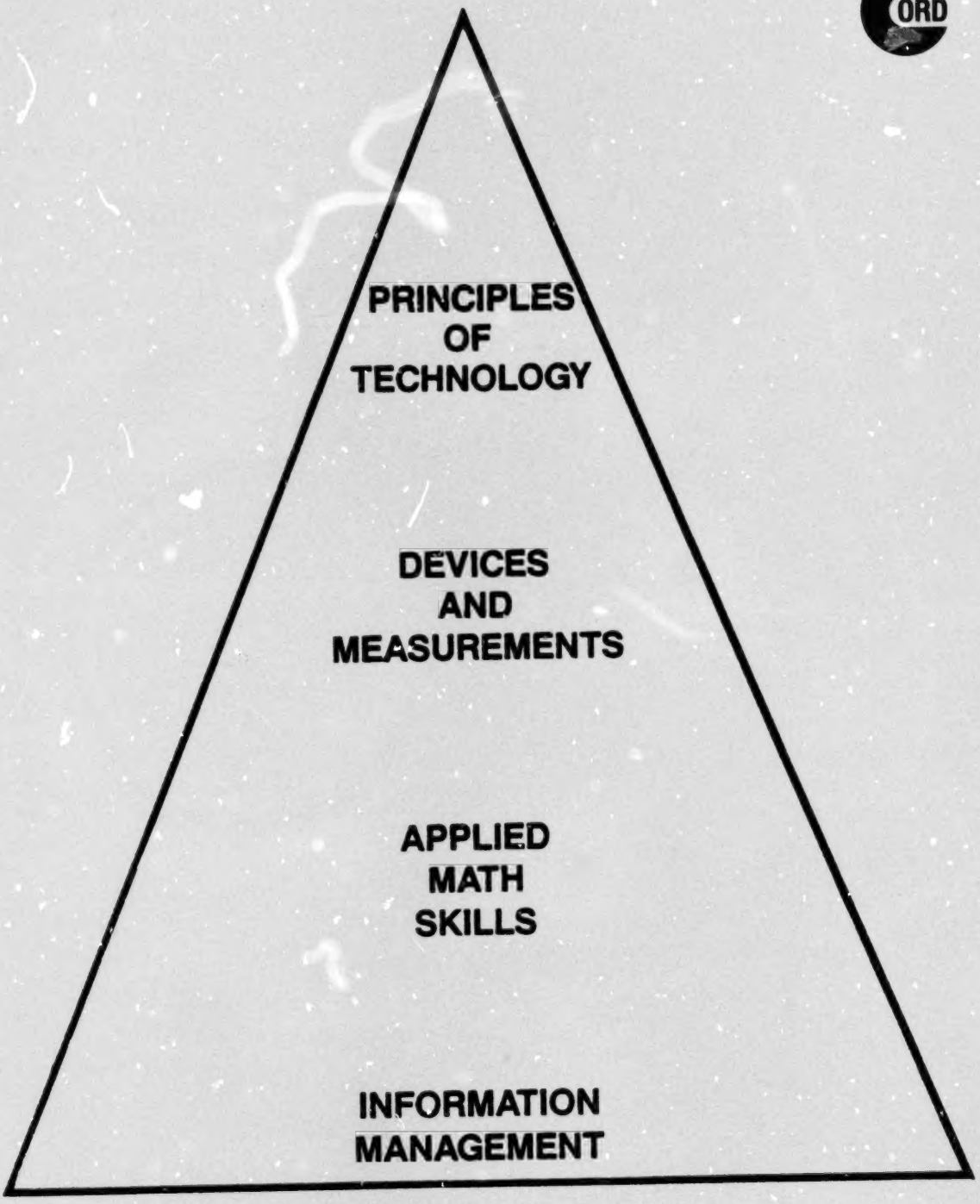

• LIBERAL ARTS/"COLLEGE BOUND"
• BEEF UP THE BASICS (R R R)
• NO RELEVANCE TO OR PREPARATION FOR WORK
• PREDICTED LOSS OF STUDENT INTEREST AND INCREASE OF DROPOUT RATE
EXTREME
EXTREME
• HIGHLY SPECIALIZED PROGRAM
• CURRENT EMPLOYABLE SKILLS
• ENTRY-LEVEL JOBS
• LITTLE PREPARATION FOR ADVANCEMENT
• NO FLEXIBILITY FOR ADAPTATION TO NEW AND CHANGING JOBS
NO MIDDLE GROUND

SINGLE-TRACK HIGH SCHOOL PLAN

TRADITIONAL VOC-ED APPROACH



MODEL FOR OCCUPATIONAL TRAINING



SUGGESTED CORE COURSES

APPENDIX D. RESOURCE ADDRESSES

U.S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS PUBLICATIONS

GENERAL PUBLICATIONS

Occupational Outlook Handbook 1982-83 Edition	Bulletin No. 2200	$9.00 (Paperback)
Handbook of Labor Statistics	Bulletin No. 2175	$9.50
Economic Projections to 1990 (1982)	Bulletin No. 2121	$6.50
Workers, Jobs, and Statistics Questions and Answers on Labor Force Statistics (1983)	Report 698	*
Youth Unemployment: A Look At The Data (1983)	Report 695	*
Current BLS Publications (A listing of selected current publications with order form)		*

SUBSCRIPTION SERVICES (Single copies may be ordered)

Employment and Earnings (Monthly Report)	$39.00
Occupational Outlook Quarterly	$ 9.00
Monthly Labor Review	$26.00
Employment in Perspective: Minority Workers (Quarterly)	*
Employment in Perspective: Working Women (Quarterly)	*

*Singles copies are available without charge from BLS Regional Offices.

INDEPENDENT PUBLICATIONS

Careerism WWWWW/Information Services, Inc. Box 10046 Rochester, NY 14610	10 times/year	$65.00
Careers, Inc. P.O. Box 315 Largo, FL 34294-0135	1-8 page brochures on specific occupations	--
Council for Career Planning 310 Madison Ave. New York, NY 10017	Brochures	--
Business Week Guide to Careers Patricia Guinn Suite 4084 1221 Avenue of the Americas New York, NY 10020	Quarterly	$10.00
Vocational Training News (formerly Education and Work) Capitol Publications, Inc. Arlington, VA 22209	Weekly	$113.00
Washington Research Associates P.O. Box 32096 Washington, DC 20007	Brochure (11 published so far)	Full Service Subscription $75.00

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TEXAS	Mr. Horace Goodson, Chief Economic Research and Analysis Texas Employment Commission 1117 Trinity Street Austin, Texas 78701	(512) 397-4540
UTAH	Mr. Richard Arnold, Director Research and Analysis Department of Employment Security P.O. Box 11249 Salt Lake City, Utah 84147	(801) 533-2014
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WYOMING	Mr. Bill Davis, Chief Reports and Analysis Section Employment Security Commission P.O. Box 2760 Casper, Wyoming 82601	(307) 237-3703

APPENDIX E.
SAMPLE LETTERS—HIGH-TECH CAREER INFORMATION SEARCH

SAMPLE LETTER TO HIGH-TECH COMPANIES

The (school or sponsoring education agency) is seeking to provide current, specific information about high-tech careers to junior high and high school guidance counselors, who in turn will supply this information to interested students. The premise of this and all career guidance activities is that students who obtain accurate information on prospective careers are better able to make wise career decisions, to elect the appropriate courses of study in secondary and postsecondary schools, and to apply themselves more effectively to the chosen curriculum. As a result, they are more likely to become well-prepared, realistic, and suitably goal-oriented employees.

We would like to make available to counselors resources from high-technology firms in (state or city). Such resources as guided tours, films, filmstrips, video cassettes, microfiche, and printed matter concerning high technology are of interest. We would also like to indicate the availability of speakers on topics ranging from specific career opportunities to general technological innovations that may spawn new careers. We are interested in providing information about high-tech careers at every level--operators, technicians, engineers, and scientists. We are especially eager to provide career information to vocational and technical students.

We are providing the attached form for your convenience in responding to our career information search. Please mail the completed form to (agency or school) (address given on form). Thank you for your interest and cooperation.

Sincerely,

(SCHOOL OR SPONSORING EDUCATION AGENCY)
HIGH-TECH CAREER INFORMATION SEARCH

NAME OF COMPANY _____

_____

ADDRESS _____

_____

OFFICE/POSITION TITLE OF COMPANY REPRESENTATIVE TO CONTACT _____

_____ _____

_____ TELEPHONE CONTACT _____

AVAILABLE RESOURCES AND SERVICES Please list services and/or resources that your company can provide to school guidance counselors who are making high-technology careers meaningful and visible to junior high and senior high school students. State costs or qualifying circumstances, if applicable. If your company has not developed prepackaged educational materials but is willing to be contacted for speakers, please indicate this.

_____

_____

_____

_____

_____

_____

_____

Mail Form to:

SAMPLE LETTER TO PROFESSIONAL SOCIETIES

The (school or sponsoring agency) is seeking to provide students with current, specific information about high-tech careers. Such resources as posters, brochures, filmstrips, and other printed and audiovisual materials are of interest. We wish to provide information about high-tech careers at every level--operators, technicians, engineers and scientists. We are especially eager to provide career information to vocational and technical students.

Thank you for your assistance in providing this information.

Sincerely,